

# SILICIFIED LOWER DEVONIAN TRILOBITES FROM NEW SOUTH WALES

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**ABSTRACT.** A silicified trilobite fauna, consisting of eighteen taxa belonging to at least fifteen genera, is described from the limestones of the upper Lochkovian to lower Pragian Garra Formation, in the vicinity of Wellington Caves, New South Wales, Australia. Seven new species are described: *Proetus (Comiproetus) irroratus*, *Otarion listron*, *Otarionella taganon*, *Acanthopyge (Lobopyge) australiformis*, *Paciphacops microps*, *Leonaspis wellingtonensis*, and *Koneprusia brikelos*. Species of *Proetus (Comiproetus)*, *Otarionella*, *Primaspis (Taemasaspis)*, *Koneprusia*, and *Ceratocephala* are described for the first time from Pragian strata in Australia. These additions support the views of Campbell and Davoren (*in* Talent *et al.* 1972) that the Lower Devonian trilobite faunas of Australia have their greatest affinities with the 'Old World' faunas of North Africa and central Europe, although recent work has shown that there are also affinities with faunas from Japan. The pygidium of a new, unnamed species of *Acanthopyge (Lobopyge)*, from the Zichovian Warroo Limestone of the Taemas Formation, near Good Hope, is illustrated and discussed.

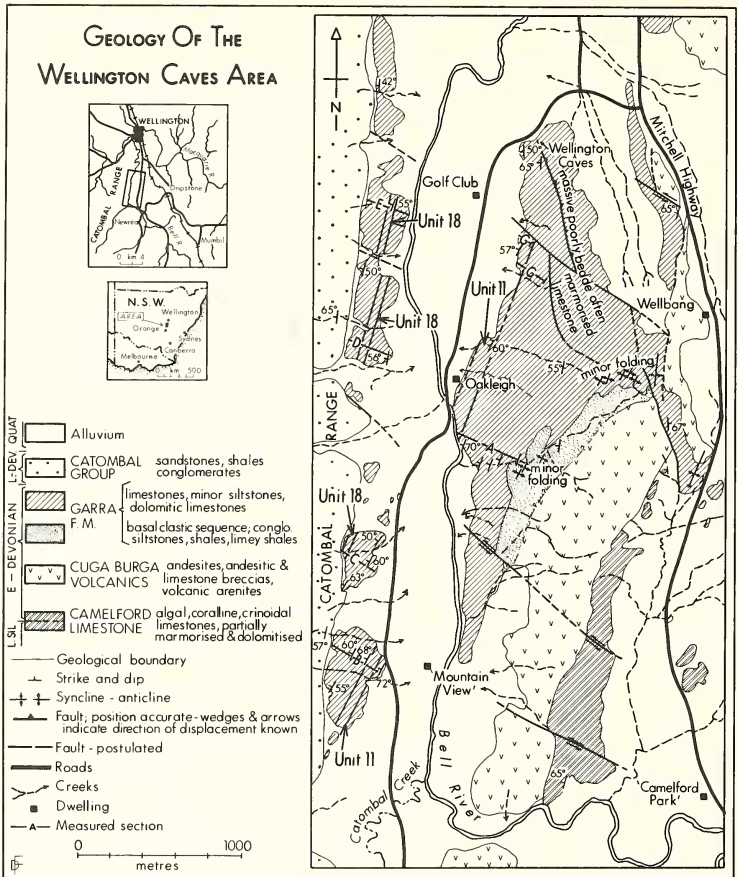
THE trilobites described here were recovered during a palaeoecological study of the silicified invertebrate faunas in limestones belonging to the Lower Devonian Garra Formation of the Wellington Caves area, 8 km south of Wellington, New South Wales (text-fig. 1). These limestones form part of an easterly tract of the Garra Formation, which consists of north-south trending belts of limestones and shales, cropping out for 100 km from west of Orange to Geurie, north of Wellington (Strusz 1965*a*).

Near the Wellington Caves, the lower half of the Garra Formation yields diverse associations of silicified brachiopods, molluscs, and corals. With the exception of the rugose corals (Strusz 1965*b*, 1966, 1967; Strusz and Jell 1970), and the conodonts (Druce 1970), the faunas of the Garra Formation have received little attention.

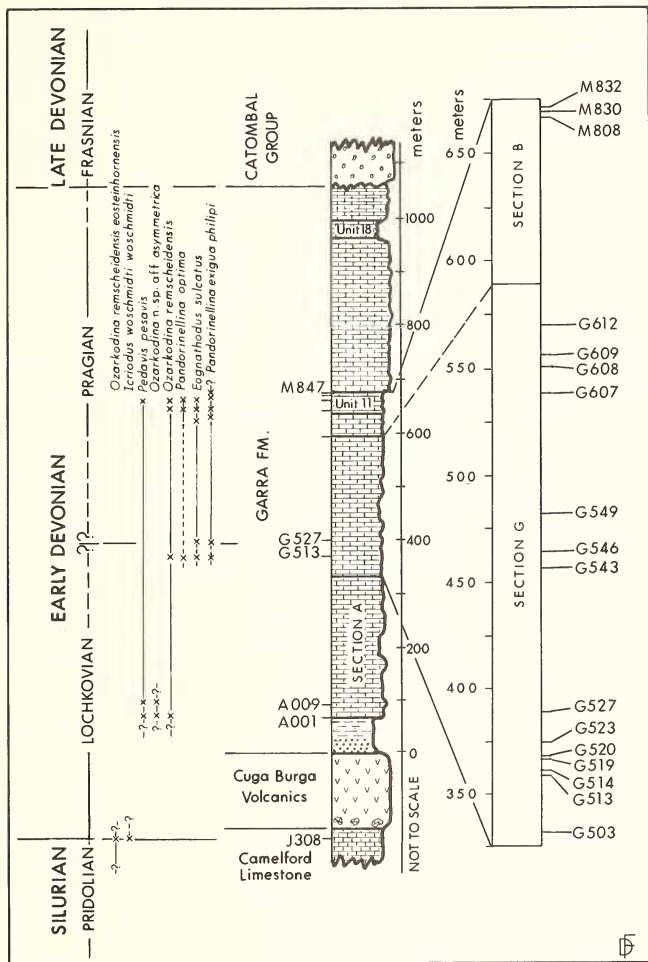
## STRATIGRAPHY AND CORRELATION

Locally (text-fig. 1), the Garra Formation is underlain by Upper Silurian-Lower Devonian Camelford Limestone and volcanic sediments and andesites of the Cuga Burga Volcanics. The basal horizons of the Garra Formation are polymictic conglomerates consistent with derivation from these lavas. These grade upwards in a transgressive sequence (Unit 1, Johnson 1975), passing through siltstones and shales to fossiliferous limy shales at the base of a carbonate sequence some 975 m in thickness. The lower half of this sequence (Units 2-11, Johnson 1975), is characterized by thinly bedded limestones deposited sub-tidally on a shallow platform. The upper 340 m of this part of the section includes the horizons with silicified fossils (text-fig. 2). Analysis of the faunas and the lithological sequence (Johnson 1975) indicates a gradual shallowing through this 'silicified interval'.

This shallowing reached inter-tidal and supra-tidal levels in the upper part of the formation and resulted in the deposition of a thick sequence of massive, poorly



TEXT-FIG. 1. Geological map, showing the locations of sections measured through the Garra Formation near Wellington Caves. On the legend L.— = late; and E.— = early.



TEXT-FIG. 2. Composite section through the Garra Formation in the vicinity of Wellington Caves, showing the stratigraphical occurrences of biostratigraphically significant conodont taxa, and the horizons of collections containing the silicified trilobites discussed in this paper.

fossiliferous limestones and dolomitic limestones in a dessicated sabkha-type environment (Units 12–17, 19–20, Johnson 1975). Similar conditions prevailed in the area until the end of 'Garra time' with only a late, brief sub-tidal episode (Unit 18, Johnson 1975).

Mild tectonism, resulting in folding, uplift, and erosion occurred presumably during the Middle Devonian, prior to the influx, during the late Devonian (Frasnian) of thick, quartz-rich, 'red bed' style clastic sediments (the Catombal Group). The Catombal Group rests with angular unconformity on the eroded surface of the Garra Formation.

Precise correlation with European and North American Lower Devonian sequences has been somewhat problematical. Strusz (1968) regarded the Garra rugose corals as being Emsian (Zlichovian or younger) in age. Druce (1970) considered that the conodonts from the lower part of the formation give a middle Siegenian (broadly Pragian) age; samples from the upper part of the Garra Formation failed to yield any conodonts. Combining all available information, Strusz (*in Strusz et al.* 1972) concluded that the age extended from the latest Lochkovian or earliest Pragian at the base, to Zlichovian at the top.

The new discovery of *Icriodus woschmidti woschmidti* 105 m from the top of the Camelford Limestone (sample J308, see text-fig. 2), together with *Ozarkodina remscheidensis eosteinhornensis* may be taken as the beginning of the Lochkovian (Ziegler 1975, p. 159).

The basal limestone of the Garra Formation (A001) yields a rich microfauna that includes *Pedavis pesavis*, *O. remscheidensis remscheidensis*, and *Ozarkodina* n. sp. aff. *O. asymmetrica*, indicating a late Lochkovian–early Pragian age. A sample from near the base of the silicified sequence (G513) contained spathognathoid forms transitional to *Eognathodus sulcatus*, *Pandorinellina optima*, and *P. exigua philipi*, as well as *O. remscheidensis*; Druce (1970) had already described *E. sulcatus* and *P. exigua philipi* from sample horizon G527, about 28 m stratigraphically higher (conodonts are included in multielement taxa by the writers). As can be seen from text-fig. 2, all of these form species continue to near the top of the silicified horizons but, unfortunately, horizons higher than M847 have so far failed to yield any conodonts.

With the exception of *Proetus (Coniproetus) irroratus* sp. nov., whose range extends to 5·2 m above M847, all the trilobites described occur within the range-zone of *Pedavis pesavis* and *O. remscheidensis remscheidensis* and thus are late Lochkovian–middle Pragian in age. The composition of the trilobite fauna does not enable us to refine this age further.

#### BIOGEOGRAPHY

The biogeography of the Lower Devonian trilobites of Australia was discussed by Campbell and Davoren (*in Talent et al.* 1972), before this Garra Formation material was known. They concluded that the greatest similarities of the Australian Lower Devonian trilobites are with Turkey, North Africa, and central Europe. To the list of genera used then for the Pragian of Australia, we now have to add: *Proetus (Coniproetus)*, *Otarionella*, *Primaspis (Taemasaspis)*, *Koneprusia*, and *Ceratocephala*. *Gravicalymene* is to be replaced by *Apocalymene*.



including Japan as indicated by *Craspedarges*, *Gravicalymene*, *Crotalocephalina*, and other genera. The fauna characterised by these three trilobite genera defines the Tasman and Oriental trilobite subprovinces in the Lower Devonian—early Middle Devonian time'. The occurrence of *Craspedarges* in Japan is certainly of significance. This genus was first described from boulders (mainly of the Pragian Amphitheatre Group) in Cretaceous sediments at White Cliffs, north of Broken Hill, N.S.W. This is its only known occurrence in Australia. On the other hand, *Gravicalymene* (= *Apocalymene*) and *Crotalocephalina* are widespread genera and can scarcely be used to define a subprovince. It is our opinion that although the Australian Pragian faunas have much in common with those of Japan, there is no reason to group them together in a subprovince that excludes North Africa and Bohemia.

Although the Canadian Arctic and Alaska have Pragian faunas of basically Old World type, and they include such genera as *Proetus* (*Coniproetus*), *Otarionella*, *Acanthopyge*, and *Koneprusia*, there is little evidence of real affinity with Australian faunas. Those genera, that are common to the two regions, occur also in central Europe and North Africa. In addition, the highly distinctive genera *Schizoproetoides*, *Lacunoporaspis*, and *Ganinella* have not been found in Australia.

We see no reason to alter the views on faunal affinity expressed by Campbell and Davoren (*in* Talent *et al.* 1972).

#### SYSTEMATIC PALAEOLOGY

Family SCUTELLUIDAE Richter and Richter, 1955

Genus SCUTELLUM Pusch, 1883

*Type species.* *Scutellum costatum* Pusch, from the Givetian of Germany.

#### *Scutellum* sp.

1964 *Scutellum* (*Scutellum*) sp. indet. Strusz, p. 92, pl. 1, fig. 1.

*Discussion.* This species is from the limestone facies of the Garra Formation, but it has not turned up in our material. The single pygidium described by Strusz has been compared with *S. calvum* from Taemas by Chatterton (1971), who nevertheless noted that they are specifically distinct.

Family PROETIDAE Salter, 1864

Subfamily PROETINAE Salter, 1864

Genus PROETUS Steininger, 1831

Subgenus PROETUS (CONIPROETUS) Alberti, 1966

*Type species.* *Proetus condensus* Přibyl, 1965 (= *P. glandiferus* Novák, see Owens 1973, p. 10) from the upper Koněprusy (early Emsian) of Czechoslovakia.

*Discussion.* This subgenus has been discussed recently by Owens (1973), Chatterton and Perry (1977), and Campbell (1977).

*Proetus (Coniproetus) irroratus* sp. nov.

Plate 104, figs. 1-21

*Holotype.* Cranidium ANU35131 from loc. M832.

*Paratypes.* ANU35132-35137, 35139, 35148, from loc. M832; ANU35138, 35142, from loc. M808; ANU35143-35144, from loc. G607; ANU35147-35148, from loc. G520.

*Derivation of name.* *irroratus*, Latin, covered with granules.

*Diagnosis.* Glabella tapering markedly towards the anterior, the width at furrow 3s being approximately three-quarters of the occipital width; lateral occipital lobes strongly developed; suture line with  $\gamma$ - $\delta$  tending to be straight in dorsal view, and inclined at 45° to the axial line;  $\delta$ - $\epsilon$  somewhat more curved, giving the palpebral lobe a small appearance despite its normal length;  $\epsilon$ - $\xi$  very steep, with  $\xi$  situated at about the mid length (exsag.) of the lateral occipital lobe; glabellar ornament finely tuberculate; eye large; socle convex, about half the height of the visual surface; genal spine strong in juveniles, short to absent in adults; ornament of fixed and free cheeks pitted and veinose inside the border furrow; doublure of free cheek with a deep, long panderian notch and a broad shallow vincular furrow running from just in front of the notch to a point below  $\beta$  where it gradually fades; rostral plate almost triangular; hypostome outline not expanded at the posterior wings, and well-rounded without marginal spines posteriorly; pygidium with eight rings plus a terminus; a distinct muscle spot near each end of each pygidial ring; border well developed and separated by a broad shallow furrow; pleural furrows about twice as deep as the interpleural furrows; anterior and posterior pleural bands approximately equal; ornament sparse and much finer than that on the glabella.

*Discussion.* In the specimens assigned to this species, there is some variation in the degree of taper of the glabella, and angularity (or spinosity) of the genal region, and the definition of the pygidial border. Though much of this variation is between specimens from a single horizon, its range is extended when all the horizons are taken into account, and it may be possible to separate out subspecies if more material becomes available.

The species clearly falls within the definition of *Coniproetus* as given by Owens (1973, p. 10). One significant feature that has not been recorded previously is the pronounced furrow in the doublure of the free cheek. In this furrow the terrace lines are suppressed, and its orientation is such that it could receive the margin of the pygidium on enrollment. It has therefore been referred to as a vincular furrow in the diagnosis. Such a structure is known also in *P. (C.) whittakerensis* Chatterton and Perry (see below), but it is smaller in that species. It may turn out to be of generic importance.

Few species of the subgenus are well known, and detailed comparisons with those species that are known only from cranidia (see G. K. B. Alberti 1969) are not warranted. *P. (C.) irroratus* may be distinguished from the type species, *P. condensus* Přibyl, by its more strongly tapered glabella, more posteriorly placed eyes, shorter genal spines, flatter pygidial axial rings, and less impressed muscle scars on the axial rings. It has more in common with *P. (Coniproetus)* sp. from the Haragan Formation

of Oklahoma (Campbell 1977), but that species is not so strongly ornamented, has longer palpebral lobes that are placed further back, a longer and more concave anterior border, and a more elongate pygidium with a more rounded posterior extremity. The Japanese material described by Kobayashi and Hamada (1977) has little in common with our new species.

*P. (C.) whittakerensis* from the Delorme Formation (Lochkovian) of the Mackenzie Mountains, Northwest Territories, is very similar in gross morphology, but *P. (C.) irroratus* can be distinguished from it by less pronounced terrace lines on the cephalic margin, less well-defined pygidial interpleural furrows, apparently less acute tip of the pygidial axis, and in not having a post-axial ridge impinging on to the pygidial border (see Chatterton and Perry 1977).

An unnamed species of the genus from the lower Emsian of the Armorican Massif has been described by Morzadec (*in Le Menn et al.* 1976). It has much reduced sculpture on the pygidium and relatively long genal spines.

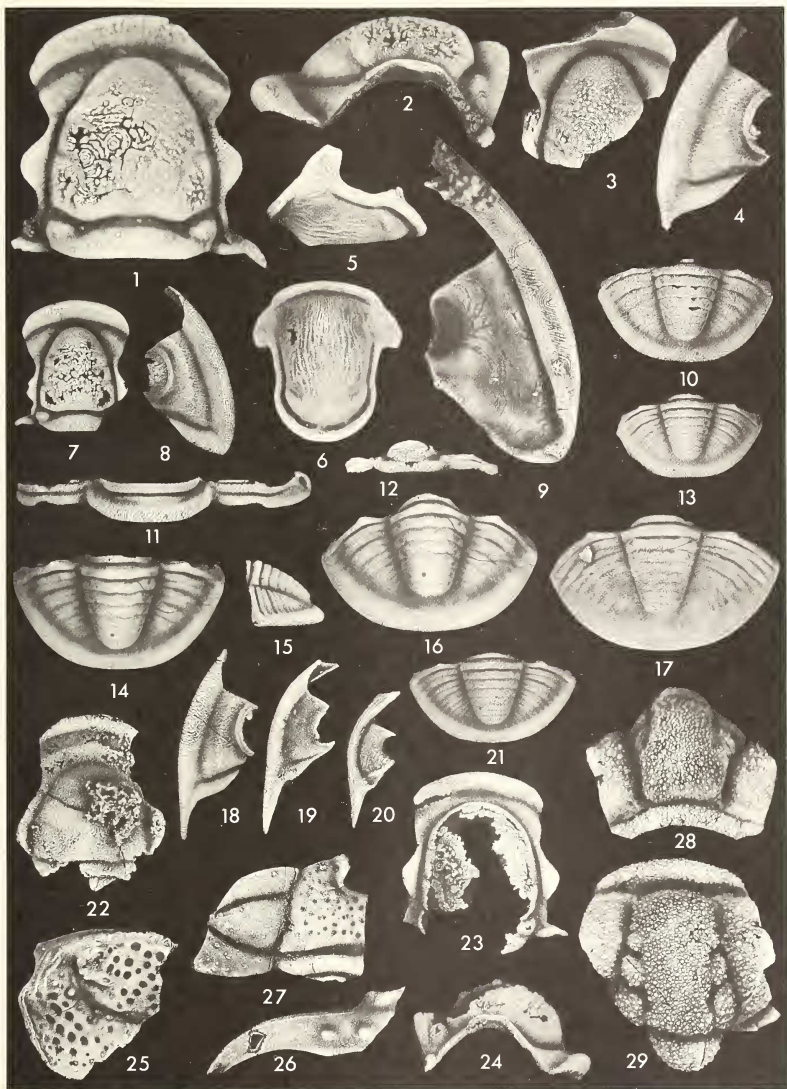
Family OTARIONIDAE Richter and Richter, 1926  
Subfamily OTARIONINAE Richter and Richter, 1926

*Discussion.* All the material of this subfamily consists of isolated free cheeks and cranidia, except for one fragmentary cephalon and one isolated thoracic segment. Despite this it is possible to recognize one species of *Otarionella* and three species of *Otarion*. The association of the cheeks and the cranidia of *Otarionella* is obvious because of the marginal tubercles. The one associated specimen of *Otarion listron* sp. nov. is sufficiently well preserved to permit the identification of the isolated elements. From the one block of limestone there are cranidia and matching free cheeks, some

EXPLANATION OF PLATE 104

- Figs. 1–21. *Proetus (Coniproetus) irroratus* sp. nov. 1, 2, ANU35131, dorsal and lateral views of holotype cranidium,  $\times 5$ , from M832. 3, ANU35132, dorsal view of cranidium fragment,  $\times 5$ , from M832. 4, ANU35133, external view of free cheek,  $\times 5$ , from M832. 5, 6, ANU35141, lateral and ventral views of hypostome,  $\times 5$ , from M830. 7, ANU35142, dorsal view of cranidium,  $\times 3$ , from M808. 8, ANU35138, external view of free cheek,  $\times 3$ , from M832. 9, ANU35134, internal view of free cheek,  $\times 5$ , from M832. 10, ANU35136, dorsal view of pygidium,  $\times 3$ , from M832. 11, ANU35135, dorsal view of thoracic segment,  $\times 5$ , from M832. 12, ANU35144, dorsal view of thoracic segment,  $\times 5$ , from G607. 13, ANU35140, posterodorsal view of pygidium,  $\times 3$ , from M832. 14, 15, 16, ANU35137, dorsal, lateral, and posterodorsal views of pygidium,  $\times 3$ , from M832. 17, ANU35143, posterodorsal view of pygidium,  $\times 5$ , from G607. 18, ANU35139, external view of free cheek,  $\times 5$ , from M832. 19, ANU35146, external view of free cheek,  $\times 5$ , from G520. 20, ANU35147, internal view of free cheek,  $\times 5$ , from G520. 21, ANU35148, dorsal view of pygidium,  $\times 3$ , from M832.
- Fig. 22. Proetid gen. et sp. indet. ANU35152, dorsal view of cranidium,  $\times 9$ , from G609.
- Figs. 23, 24. *P. (Coniproetus)?* sp. ANU35145, dorsal and lateral views of incomplete cranidium,  $\times 5$ , from G607.
- Figs. 25, 26. Lichid gen. et sp. indet. 25, ANU35151, ventral view of hypostome,  $\times 3$ , from G503. 26, ANU35150, dorsal view of incomplete thoracic segment,  $\times 3$ , from G503.
- Fig. 27. Cheirurid gen. et sp. indet. ANU35153, dorsal view of cranidium fragment,  $\times 3$ , from G514.
- Figs. 28, 29. *Apocalymene* sp. A. ANU35149, anterior and dorsal views of incomplete cranidium,  $\times 5$ , from G520.





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slightly smaller than the others, indicating a growth series of *O. listron*. There are two quite distinctively shaped free cheeks for which no cranidia can be recognized. This latter form is described as *Otarion* sp. A. Two fragmentary cranidia that lack ornament are referred to a second species, *Otarion* sp. B.

### Genus OTARION Zenker, 1833

*Type species. Otarion diffractum* Zenker from the Kopanina Limestone (Ludlow) of Czechoslovakia.

#### *Otarion listron* sp. nov.

Plate 105, figs. 1-4, 6-13, 25

*Holotype.* Incomplete cranium and free cheek ANU35180 from loc. G523.

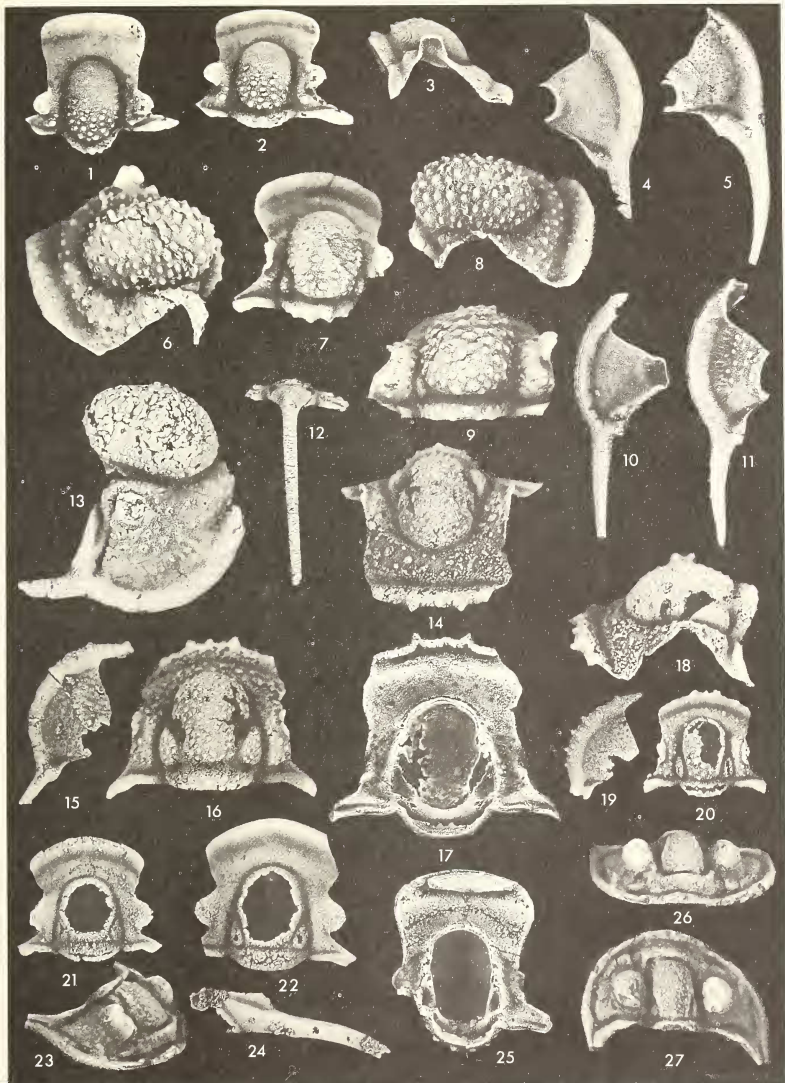
*Paratypes.* ANU35208 from loc. G609; ANU35209-35213 and 35218-35219 from loc. G546; ANU35215-35216 from loc. G543; ANU35217 from loc. G607.

*Derivation of name.* *listron*, Greek, shovel, from a fancied resemblance of the juvenile cranidia.

*Diagnosis.* Moderately convex glabella in juveniles, strongly convex in both longitudinal and lateral profiles in adults; convex and steep preglabellar field; glabellar lobes lp weak, extending forwards only as far as the rear edge of the palpebral lobes; facial suture with  $\beta$  broadly rounded and on the anterior border;  $\alpha$ - $\alpha$  about width of the occipital ring; connective sutures strongly convergent so that rostral plate is only one sixth times as wide posteriorly as anteriorly;  $\omega$  situated well inside base of genal spine; genal spine with slight posterolateral deflection, almost equal in length to the remainder of the cheek in juveniles but proportionately shorter in adults, slightly ovate in cross section proximally and circular distally; occipital ring with an enlarged median tubercle flanked by numerous closely spaced smaller tubercles; in juveniles

#### EXPLANATION OF PLATE 105

- Figs. 1-4, 6-13, 25. *Otarion listron* sp. nov. 1-3, ANU35171, anterodorsal, dorsal and lateral views of cranium,  $\times 5$ , from G520. 4, ANU35172, external view of free cheek,  $\times 5$ , from G609. 6, 9, ANU35174, anterodorsolateral and dorsal views of cranium,  $\times 5$ , from G520. 7, 25, ANU35175, dorsal and ventral views of cranium and rostral plate,  $\times 5$ , from G520. 8, ANU35176, dorsolateral view of broken cranium,  $\times 5$ , from G520. 10, ANU35177, internal view of free cheek,  $\times 5$ , from G609. 11, ANU35178, external view of free cheek,  $\times 5$ , from G520. 12, ANU35179, dorsal view of thoracic segment with broken pleurae,  $\times 5$ , from G514. 13, ANU35180, dorsolateral view of holotype broken cranium and free cheek,  $\times 5$ , from G523.
- Fig. 5. *Otarion* sp. A. ANU35173, external view of free cheek,  $\times 5$ , from G520.
- Figs. 14-20. *Otarionella taganon* sp. nov. 14, 16, 17, 18, ANU35181, anterodorsal, dorsal, ventral, and dorsolateral views of holotype cranium,  $\times 5$ , from G513. 15, ANU35182, external view of free cheek,  $\times 5$ , from G527. 19, ANU35183, external view of incomplete free cheek,  $\times 5$ , from G514. 20, ANU35184, dorsal view of cranium,  $\times 5$ , from G514.
- Figs. 21, 22. *Otarion* sp. B. 21, ANU35185, dorsal view of cranium,  $\times 9$ , from G514. 22, ANU35186, dorsal view of cranium,  $\times 9$ , from G514.
- Figs. 23, 26, 27. *Otarion munroei* Strusz. SU 6935, anterodorsolateral, anterior, and dorsal views of paratype cephalon,  $\times 5$ .
- Fig. 24. Gen. et sp. indet. ANU35187, thoracic segment,  $\times 5$ , from G607.



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posterior half of glabella tuberculate, with tubercles coarse posteriorly and diminishing rapidly forwards; anterior half of glabella, preglabellar field, free cheeks, borders, and genal spines all smooth; in adults tubercles cover glabella, preglabellar field, and free cheeks, though with some slight diminution in size anteriorly and laterally, and considerable variation in their strength between specimens; borders and genal spines in adults with markedly smaller tubercles than elsewhere on the cheeks.

*Discussion.* The material of this species comes from more than ten different horizons and localities, but it is not abundant at any one. Some localities have predominantly juveniles and others adults. However, at G513 there are cranidia and cheeks showing gradation in size sufficient to convince us that the great variation in shape and ornament shown on Plate 105, figs. 1, 2 and 6-8 is ontogenetic. In this same sample there is an isolated thoracic segment with a pronounced median spine. It probably belongs to this species; though *Otarionella tagaon* also occurs with it, *Otarionella* is not known to have such a segment.

Comparisons with overseas species are not very meaningful because details are often missing. Among Australian species, *Otarion dabrowni* Chatterton from the *Receptaculites* Limestone is distinguished by its shorter preglabellar field, more divergent anterior branches of the facial sutures, and finer, more closely spaced tubercles on the cheeks. The late Silurian and basal Devonian species described by Mitchell (1888) and Etheridge and Mitchell (1893) also have some similarities. *O. horani* (Etheridge and Mitchell) may be distinguished by its strongly curved genal spines, longer 1p lobes and shorter preglabellar field. *O. bowningensis* Mitchell is closer in general form, but it has much larger 1p lobes, a shorter anterior border, and finer tubercles.

One might have expected *O. monroei* Strusz, 1964, previously described from shale beds in the Garra Formation, to be represented among the etched specimens, but it is not. It is easily distinguished from *O. listron* by the long, parallel-sided glabella, strongly convex preglabellar field, almost straight genal spines that are strongly furrowed proximally, and fine glabellar ornament. A paratype of *O. mouroei* is figured for comparison (Pl. 105, figs. 23, 26, 27).

*Otarion* sp. A.

Plate 105, fig. 5

*Material.* ANU35173a, b from loc. G520.

*Discussion.* These two free cheeks are distinctive in that they have the lateral and posterior border furrows joined in the genal angle, a crest on the outer dorsal side of the genal spine, a very broad base to the genal spine which shows a distinctive downwards flexure at its base, and four or five unusually coarse tubercles on the inner dorsal side of the genal spine. They also lack the tubercles below the eye shown by *O. listron*, and instead have a large number of closely spaced pits probably connected with a caecal system.

*Otarion* sp. B.

Plate 105, figs. 21, 22

*Material.* ANU35185–35186 from loc. G514.

*Description.* Glabellar profiles moderately arched; glabellar outline sub-conical; axial furrows moderately impressed throughout, but not becoming weaker opposite the palpebral lobes; occipital furrow shallow and occipital lobe rather flat in longitudinal profile; lobes 1p wide, and extending forward to about the mid length of the palpebral lobes; furrow 1s weakly but distinctly impressed; preglabellar field moderately convex, and equal in length to the anterior border; 2s furrows shallow; anterior border furrow shallow and well rounded; palpebral lobes rising gently and separated off by very weak palpebral furrows; a tiny pit present in the centre of the palpebral lobe; cranium apparently smooth except for a possible occasional small tubercle on the 1p lobes.

*Discussion.* These forms are small, the largest cranium being only 4.5 mm long, but they are clearly not the juveniles of *O. listron* sp. nov., with which they occur. The profiles, smooth surface, and weak 2s furrows suggest a degree of similarity to *Aulacopleura* (*Paraaulacopleura*). There are obvious similarities to *A. (P.) beyrichi* Novák, especially those specimens figured by G. K. B. Alberti (1970, pl. 9, figs. 16–20) from North Africa, but insufficient of the exoskeleton is preserved to recognize this in the nomenclature. The greater similarities of *Otarion* (*Otarion*) *periergum* Haas, 1969, from the Lower Devonian of Nevada, including the low profile, pitted palpebral lobes, glabellar outline, and short, shallow 2s furrows, together with the absence of both caeca and long 2s furrows, convince us that this species belongs to *Otarion* rather than to the related *Aulacopleura* and *Paraaulacopleura*.

We draw attention to the similarity between this form and the otarionid described by Talent (1965, p. 48, pl. 24, figs. 7–8) as Proetidae indet. gen. et sp. A, from the McIvor Formation, Heathcote, Victoria.

## Genus OTARIONELLA Weyer, 1965

*Type species.* *Cyphaspis davidsoni* Barrande, 1852, from the Suchomasty Limestone, Lower Devonian, of Czechoslovakia.

*Otarionella taganon* sp. nov.

Plate 105, figs. 14–20

*Holotype.* Cranium ANU35181 from loc. G513.

*Paratypes.* ANU35182 from loc. G527 and ANU35183–35184 from loc. G514.

*Derivation of name.* *Taganon*, Greek, frying pan, from a fancied resemblance of the free cheek.

*Diagnosis.* Glabella markedly bell-shaped in adult; 1p lobes large, extending forward almost to the anterior edge of the palpebral lobes; 1s furrows deeply impressed; occipital ring with a median tubercle flanked by smaller tubercles; remainder of glabella with tubercles of similar size and spacing to the smaller ones on the ring; fixed cheeks with slightly larger tubercles; anterior border with two large tubercles flanking a smaller one; lateral border with five or six marginal tubercles similar in size to the median anterior tubercle; both lateral and anterior borders with additional scattered irregular tubercles; free cheeks, inside borders, with shallow pits forming a

crude reticulum, and rare tubercles; genal spine posterolaterally deflected; connective sutures very strongly convergent; rostral suture cuts across base of anterior border tubercles.

*Discussion.* This species is known only from the dorsal exoskeleton of the cephalon. The specimens vary in size, but are all holaspids. There is a tendency for the tuberculation to decrease in relative strength in the larger specimens. This is particularly obvious with the marginal tubercles as shown on Plate 105, figs. 15, 19. In the size of its tubercle-like marginal spines, it is closer to the North African species described by G. K. B. Alberti (1967, 1969) than to the type species, but even so it is readily distinguished by the still smaller size of the spines and their fewer number. In addition, *Otarionella taganon* lacks the occipital spine found in these species. *O. stephanum* (Lütke) from the Harz Mountains (Lütke 1965) and the Armorican Massif (Pillet 1972) also has an occipital spine and larger marginal spines.

#### Family CHEIRURIDAE Salter, 1864

##### Cheirurid gen. et sp. indet.

Plate 104, fig. 27; Plate 108, figs. 26, 27

*Material.* ANU35168-35169 from loc. G520; ANU35153 from loc. G514.

*Discussion.* These fragments of a free cheek, part of a cranidium, a hypostome, and half a thoracic segment all probably belong to the same species. The long anterior extension on the free cheek suggests a morphology of the *Cheirurus* (*Crotalocephalina*) *gibbus* type. This is supported by the length/width ratio of the thoracic pleura, which indicates that the thorax was a relatively narrow structure over all.

Strusz (1964) described several isolated cranidia from the silty phase of the Garra Formation as *C. (Crotalocephalus) packhami*. The type material is lost.

#### Family HARPIDAE Hawle and Corda, 1847

##### Harpid gen. et sp. indet.

Plate 108, fig. 28

*Material.* ANU35170 from locality G513.

*Discussion.* A single fragment of the posterior tip of a cephalic prolongation was found. This fragment apparently came from a harpid with a subrounded and rather blunt tip to the cephalic prolongation. The ornament consists of distinct, equally spaced pits. The blunt termination of this fragment prevents it being included in such Devonian genera as *Harpes* and *Lioharpes*.

#### Family CALYMENIDAE Burmeister, 1843

##### Genus APOCALYMENE Chatterton and Campbell, 1979

*Type species.* *Apocalymene coppinsensis* Chatterton and Campbell from the Walker Volcanics (Wenlock) of Canberra, Australia.

*Discussion.* This genus has been discussed in detail by Chatterton and Campbell (1979) who took into account this material in their formulation of the generic concept.

Four specific names are available for Gedinnian-Siegenian members of the genus from south-eastern Australia: *angustior* Chapman, 1915; *australis* Etheridge and Mitchell, 1917; *hetera* Gill, 1945; *kilmorensis* Gill, 1945. From published data it is impossible to be sure of the specific characters of any of these species, and the group needs to be revised as a unit. Until this is done it is inappropriate to describe any new Lower Devonian species even though they could be based on more adequate material, such as the silicified specimens from the Garra Formation.

The genus is represented by two quite distinct species within the Garra Formation, the two occurring together at some localities. Since all the material is dissociated there is some difficulty with the assignment of rostral plates and hypostomes, but the free cheeks, cranidia and pygidia can all be easily associated on the ornament patterns.

*Apocalymene* sp. A.

Plate 104, figs. 28, 29; Plate 106, figs. 10, 16-27

*Material.* ANU35199, 35206 from loc. G514; ANU35195, 35201, 35203-35205 from loc. G513; ANU35201 from loc. G607; ANU35149, 35202 from loc. G520.

*Description.* Glabella moderately inflated; preglabellar furrow deep and narrow; anterior border standing very steeply and tightly rolled without any flattening on the crest; in anterior profile rostral suture approximately forming the arc of a circle; palpebral lobes only slightly raised and situated with  $\delta$ - $\delta$  passing through 2s; free cheeks as for the genus; ornament of dorsal surface of cephalon of irregularly spaced small tubercles separated by finer tubercles or granules; closely spaced fine tubercles covering the lateral borders, but coarser ones on the anterior border.

Rostral plate with border sector standing steeply and set at an angle of about 40° to the doublure sector; ratio of posterior width to anterior width of border sector about 3:7; doublure sector only slightly scooped out and with slightly thickened projections as its lateral extremities; connective sutures strongly curved. Hypostome with large anterior wings; width across posterior wings only three-fifths that across anterior wings; anterior border with a high upturned edge to the hypostomal suture; a thickened, flattened projection at each extremity to meet the similar structures at the extremity of the doublure sector of the rostral plate; middle body short, only moderately convex and entirely devoid of a median knob or process; median furrow weak; lateral borders tightly rolled; posterior median notch reaches forwards to middle body; posterior spines (both broken on the only specimen available) broad based and acute; surface mainly smooth but with a few weak tubercles on the lateral borders and posterior half of the middle body.

Pygidium with axis 0.4-0.45 times the total width; five axial rings plus a terminus; four distinct pleural furrows, the fifth combining with the next interpleural furrow in the normal manner; postaxial ridge prominent, not well separated from the axis, and bearing faint traces of pleural segmentation; interpleural furrows barely distinguishable proximally, more prominent towards the margin; a distinct but slight furrow, representing the position of the overlap of the edge of the cephalic doublure, completely encircling the pygidium; ornament on axis and pleurae of fine tubercles becoming slightly weaker and more closely spaced on the border.

*Discussion.* The rostral plate has been assigned to this species because of the shape of the rostral suture, the fit between the postaxial ridge of the pygidium and the inner edge of the border sector, and the fine ornament. The hypostome has then been assigned because its great anterior width accords better with the wide edge on the doublure sector of this rostral plate than with the narrow one of *Apocalymene* sp. B.

A feature not previously described in this group is the thickening of the extremities of the hypostome and the rostral plate at the rostral suture to make two clear points of articulation in addition to those between the pits on the anterior wings and the so-called antennular pits (see Pl. 106, fig. 10). With such articulation the hypostome would have been capable of very limited movement only.

*Apocalymene* sp. B.

Plate 106, figs. 1-9, 11-15

*Material.* ANU35192, 35194, 35197 from loc. G513; ANU35190, 35191, 35193, 35196 from loc. G523; ANU35189 from loc. G520.

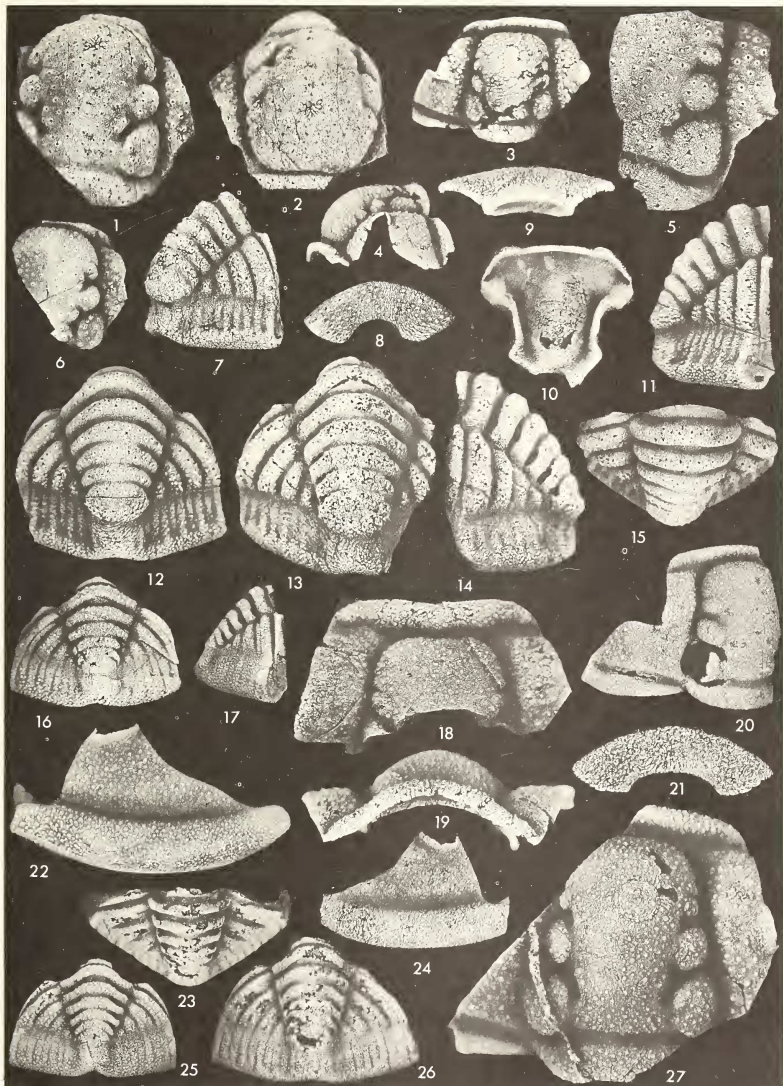
*Discussion.* This species is represented by more fragmentary material than *Apocalymene* sp. A, but most fragments can be easily recognized. *Apocalymene* sp. B. differs from *A.* sp. A in having a more strongly convex glabella; larger more scattered tubercles with large perforations on the glabella, genal lobe, and borders; a slightly shorter and deeper anterior border furrow; a rostral plate with a coarser perforate ornament, and an inner edge that is curved more distinctly in a tighter curve than the outer (anterior) edge; a pygidium with a wider and more inflated axis that is more distinctly defined posteriorly by a furrow that runs forward subhorizontally from the axis, forming a type of vincular furrow (for coaptation with the inner edge of the rostral plate); indistinct or very shallow interpleural furrows inside the vincular furrow; a depressed portion of the pleura, extending from the vincular furrow almost to the margin, with distinct pleural and interpleural furrows; a more distinctly convex postaxial ridge; and an ornament of larger perforated tubercles on the axis and inner parts of the pleurae and finer perforated tubercles on the distal portions of the pleurae.

This species is easily distinguished from all those previously described from Australia by the coarsely perforated tubercles and the distinctively furrowed

EXPLANATION OF PLATE 106

- Figs. 1-9, 11-15. *Apocalymene* sp. B. 1, 2, ANU35188, dorsal and anterodorsal views of cranium,  $\times 2$ , from G514. 3, 4, ANU35189, dorsal and lateral views of cranium,  $\times 5$ , from G520. 5, ANU35190, dorsal view of cranium fragment,  $\times 5$ , from G523. 6, ANU35191, dorsal view of cranium fragment,  $\times 3$ , from G523. 7, ANU35192, posterolateral view of pygidium fragment,  $\times 3$ , from G513. 8, ANU35193, ventral view of rostral plate,  $\times 2.5$ , from G523. 9, ANU35194, posteroventral view of rostral plate,  $\times 5$ , from G513. 11, 12, 15, ANU35196, lateral, posterior, and dorsal views of pygidium,  $\times 3$ , from G523. 13, 14, ANU35197, posterodorsal and lateral views of pygidium,  $\times 3$ , from G513.
- Figs. 10, 16-27. *Apocalymene* sp. A. 10, ANU35195, ventral view of hypostome,  $\times 3.5$ , from G513. 16, 17, ANU35198 (specimen missing), posterior and lateral views of pygidium,  $\times 3$ , from G513. 18, 19, ANU35199, dorsal and anterior views of cranium fragment,  $\times 5$ , from G514. 20, ANU35200, dorsal view of incomplete cranium,  $\times 5.5$ , from G607. 21, ANU35201, ventral view of rostral plate,  $\times 5$ , from G513. 22, ANU35202, external view of free cheek,  $\times 5$ , from G520. 23, 26, ANU35203, dorsal and posterior views of pygidium,  $\times 3$ , from G513. 24, ANU35204, external view of free cheek,  $\times 3.5$ , from G513. 25, ANU35205, posterior view of pygidium,  $\times 3$ , from G513. 27, ANU35206, dorsal view of incomplete cranium,  $\times 5$ , from G514.





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pygidium. It may be thought that the species does not fall within the concept of the genus in that the axis is well defined posteriorly. We believe that this definition is a secondary one resulting from the coaptation of the pygidium with the unusually narrowly confining posterior edge of the rostral plate.

Family PHACOPIDAE Hawle and Corda, 1847

Genus PACIPHACOPS Maksimova, 1972

Subgenus PACIPHACOPS (PACIPHACOPS) Maksimova, 1972

*Type species. Phacops logani* Hall from the Lower Devonian of North America.

*Discussion.* This genus has been discussed in detail recently by Campbell (1977).

*Paciphacops (Paciphacops) microps* sp. nov.

Plate 107, figs. 1-24

*Holotype.* Cephalon ANU35207 from loc. G609.

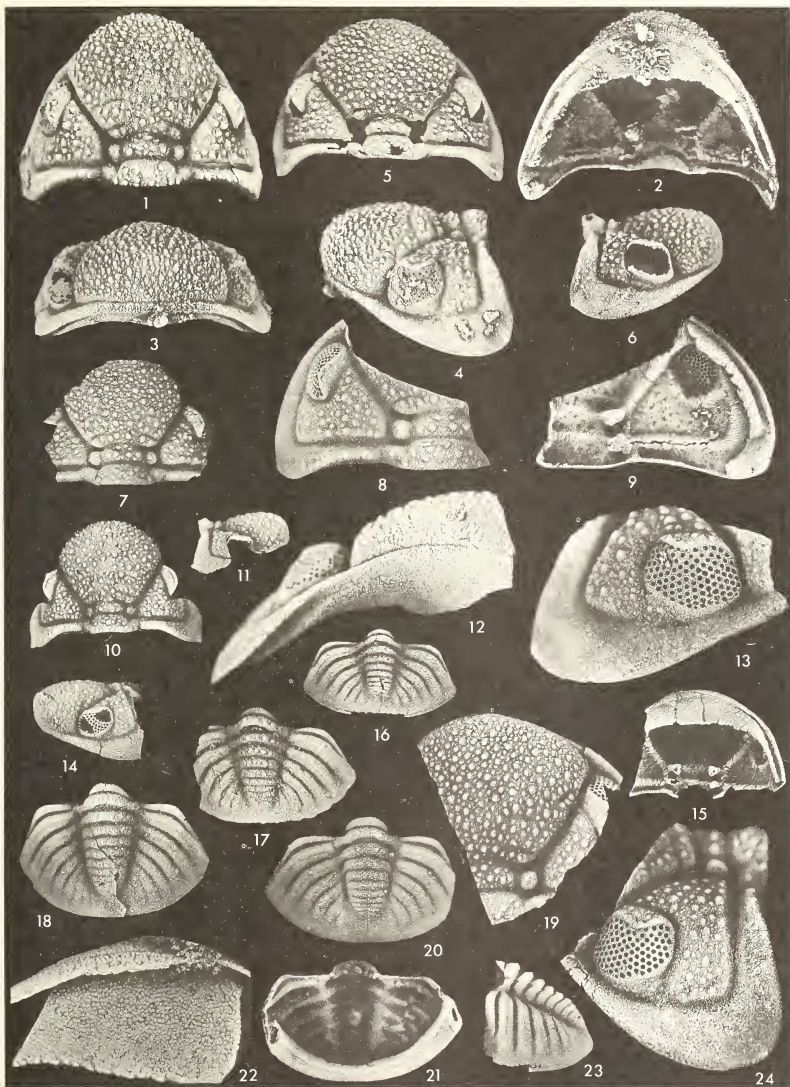
*Paratypes.* ANU35208 from loc. G609; ANU35209-35213 and 35218-35219 from loc. G546; ANU 35215-35216 from loc. G543; ANU35217 from loc. G607.

*Derivation of name.* *micro*, Greek, small; *ops*, Greek, eye

*Diagnosis.* Glabella with axial furrows diverging at 65°-70° in front of 1p, and almost semi-circular in anterior profile; lobe 1p almost as long as occipital ring; furrow 2s distinct, situated well back; furrow 3s much less distinct, but with its bipartite nature clear; eye well forward and situated with its anteroventral edge almost in the border furrow; H/A = 1.50-1.75 (see Struve 1958); 18 files of lenses, with a maximum of 7-8 per file; maximum number of lenses observed 106; average lens pattern (from front to back) is 467 677 877 766 655 442; sclera slightly depressed; genal spine represented by a slight node in adults and by a small spine in juveniles; vincular furrow entire but without distinct notches laterally. Ornament of glabella, occipital ring and fixed cheeks tuberculate; two size orders of tubercles, with small tubercles scattered sparsely between the main ones except towards the anterior extremity of the glabella where the fine ones tend to predominate; many of larger tubercles on glabella perforated (Pl. 107, fig. 1); posterior border with larger tubercles

#### EXPLANATION OF PLATE 107

Figs. 1-24. *Paciphacops (Paciphacops) microps* sp. nov. 1-4, ANU35207, dorsal, ventral, anterior, and anterodorsolateral views of holotype cephalon,  $\times 3$ , from G609. 5, 6, ANU35208, dorsal and lateral views of cephalon,  $\times 5$ , from G609. 7, ANU35209, dorsal view of incomplete cephalon,  $\times 3$ , from G546. 8, 9, 24, ANU35210, dorsal, ventral and lateral views of cephalon fragment,  $\times 3$ ,  $\times 3$ , and  $\times 4$ . 10, ANU35211, dorsal view of cranium,  $\times 5$ , from G607. 11, ANU35275, lateral view of cranium,  $\times 5$ , from G607. 12, ANU35212, anterior view of cephalon fragment,  $\times 5$ , from G546. 13, ANU35213, external view of cephalon fragment,  $\times 5$ , from G546. 14, 15, ANU35213, lateral and ventral views of incomplete cephalon,  $\times 3$ . 16, ANU35215, posterodorsal view of pygidium,  $\times 3$ , from G543. 17, ANU35216, posterodorsal view of incomplete pygidium,  $\times 4.5$ . 18, 23, ANU35217, posterodorsal and lateral views of pygidium,  $\times 5$ , from G607. 19, 22, ANU35218, dorsal and ventral views of cephalon fragment,  $\times 2.5$  and  $\times 5$ , from G546. 20, 21, ANU35219, posterodorsal and ventral views of pygidium,  $\times 5$ , from G546.



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adaxially, fine and sparser ones laterally; posterior part of lateral borders with scattered fine tubercles (almost granules), becoming finer and more densely packed towards and on the anterior border; double granule with the granules tending to become arranged in irregular rows laterally. Pygidium with nine rings plus terminus, and six distinct pleural furrows; anterior pleural band narrower (exsag.) than posterior one; border poorly defined; few scattered tubercles on rings and posterior pleural bands; remainder of surface granulose.

*Discussion.* This species is a characteristic member of *Paciphacops* (*Paciphacops*). So far as we can determine, there is no evidence of the dimorphism that commonly occurs in species of this genus.

In the length of the post-ocular fixigena, the length of lobe 1p, the lens and file numbers, and the glabellar ornament, *P. (P.) microps* is close to *Phacops* n. sp. of Talent (1963) from the Kilgower Member of the Tabberabbera Formation in eastern Victoria, and the two are probably conspecific. There is also a resemblance to the *Phacops* cf. *serratus* Foerste of Talent (1965) from the Mount Ida Formation at Heathcote, Victoria, but that material is too poorly preserved for us to be sure of its relationships.

*Phacops spedeni* Chatterton, 1971, from the younger *Receptaculites* Limestone of Taemas, N.S.W., also has a long 1p lobe, perforated tubercles, and similar double ornament, but is easily distinguished by the shorter post-ocular region, and the more or less uniform size of the glabellar tubercles, the larger eyes with a distinctive lens pattern, and the slight genal spine that persists into the adult stages. The generic assignment of *Phacops spedeni* poses something of a problem as it is intermediate between *Paciphacops* (*Paciphacops*) and *Phacops s. s.* It seems to have reached the evolutionary grade of *Phacops degener* Barrande and *Phacops turco* Richter and Richter (Haas 1968).

Among overseas species there are some that compare with *Paciphacops* (*Paciphacops*) *microps*. There are similarities with the central European species *P. (P.) veles* Chlupáč, 1972, particularly in the length of the post-ocular fixed cheek and the long lobe 1p, but the glabellar ornament, eyes, pygidial ornament, and pleural shape suggest that the two are not closely related. The French species *P. (P.) potieri* Bayle is another comparable form, but its glabellar ornament is finer, its post-ocular fixed cheek shorter, its lens count different, particularly towards the front of the eye, and the interpleural furrows on the pygidium are slightly further forward. Nevertheless, this is the most closely related of the overseas species.

Of the North American species, *P. (P.) logani clarkei* Eldredge, 1973 and *P. (P.) invius* Campbell, 1977 are the closest morphologically. Both these species have shorter post-ocular fixed cheeks and slightly different ornament patterns. In addition, lobe 1p in *clarkei* is greatly reduced, and though it has eighteen files in specimens from some localities, the number of lenses per file is higher. *P. invius* has sixteen files in the large-eyed morph, and though the number of lenses per file is comparable, there are still minor differences from *P. (P.) microps*.

What is of considerable interest in all these comparisons is the ages of the most closely allied species. These are as follows: *P. (P.) veles* from the upper Koněprusy Limestones-Siegenian; *P. (P.) potieri* from the late Siegenian-early Emsian; *P. (P.)*

*logani clarkei* from the late Siegenian; *P. (P.) invius* from the early Siegenian. In other words, *P. (P.) microps* is a characteristic late stage *Paciphacops*. Not only is this deduced by direct specific comparisons, but also by analysis of its position on the various evolutionary trends (morphoclines), such as the reduction of granulation on the glabellar tubercles, the reduction of the ornament on the pygidium, and the marked decrease in tubercles sizes from the back to the front of the glabella.

Family LICHIDAE Hawle and Corda, 1847

Subfamily CERATARGINAE Tripp, 1957

Genus ACANTHOPYGE Hawle and Corda, 1847

Subgenus ACANTHOPYGE (LOBOPYGE) Přibyl and Erben, 1952

*Type species.* *Acanthopyge (Lobopyge) branikensis* (Barrande) from the Dvorce-Prokop Limestone, Pragán, of Bohemia.

*Diagnosis.* Cephalon moderately arched and inflated; eyes not raised on protrusions; genal spines short and depressed. Pygidium approximately as long as wide, with first two pleural segments clearly defined with both anterior and posterior pleural bands convex in profile and the interpleural furrows more strongly impressed than the pleural furrows, and with short to very short backwardly swept depressed marginal spines; third segment sometimes with a vestigial spine; a pair of short spines at the posterior extremity; no border present.

*Discussion.* We have chosen to regard *Lobopyge* Přibyl and Erben as a subgenus of *Acanthopyge* for a variety of reasons. Most workers agree that they are closely related, and Tripp (1957) has regarded them as synonyms.

With *A. (Acanthopyge) s.s.*, *Lobopyge* shares a very similar cranidial lobation, similarly shaped free cheeks, and forwardly placed genal spines; broadly comparable hypostomes with transverse middle bodies; and pygidia with three pairs of relatively slender marginal spines. The differences, some of which were pointed out by Vaněk (1959, pp. 120, 127), lie in the generally greater inflation of the cephalon of *Acanthopyge*, whose cheeks are more reduced, hypostome more elongate, pygidium relatively shorter, pygidial border well developed, pygidial border spines generally more elongate and acute, and posterior pleural segments more reduced. Vaněk also suggested that there were differences in the position of the anterolateral glabellar lobes and the width of the pygidial doublure, but we have been unable to substantiate these claims. For example, our new species *A. (L.) australiformis* is very similar to *A. (L.) branikensis* in axis shape, pleural segmentation, and spine development, but has a narrow doublure like *A. (A.) haueri*; and there seems to be a gradation in the form and position of the anterolateral glabellar lobes from *A. (L.) richteri* (Vaněk) (which on pygidial characters is clearly a *Lobopyge*), through *A. (L.) pragensis* (Bouček) to *A. (L.) australiformis* and *A. (L.) branikensis*. In fact there is even gradation in some of the characters listed above as distinctive—for example the proportions of the hypostome. It seems as though there is a plexus of characters that occur in a variety of combinations in a number of related species, and although it is possible on balance to assign any given form to the *Lobopyge*-type or the *Acanthopyge*-type, it would be unwise to recognize this fact at a taxonomic level higher than the subgenus.

A similar situation obtains with respect to another subgenus of *Acanthopyge*, viz.

*A. (Mephiarges)* Richter and Richter, 1930. The species described by Edgell (1955) and Chatterton (1971) as *A. (M.) bifida*, for example, has many features in common with *A. consanguinea* (Clarke) and the *Acanthopyge* sp. of Perry and Chatterton (1976), which do not show the distinguishing characteristics of *A. (Mephiarges)*, though they do have an ornament of pits rather than tubercles on the hypostome indicating that the other similarities may not really indicate a relationship as close as has been previously suggested (Chatterton 1971; Perry and Chatterton 1976). It is nevertheless becoming increasingly difficult to diagnose *A. (Mephiarges)*, whose type species *A. (M.) mephisto* seems to be an extreme form at the end of a range of variation in a number of characters.

The relations between *Acanthopyge* and the Ordovician–Silurian *Hemiarges* have been summarized recently by Perry and Chatterton (1977, p. 307).

*Acanthopyge (Lobopyge) australiformis* sp. nov.

Plate 108, figs. 1–25

*Holotype.* Cephalon ANU35157 from loc. G609.

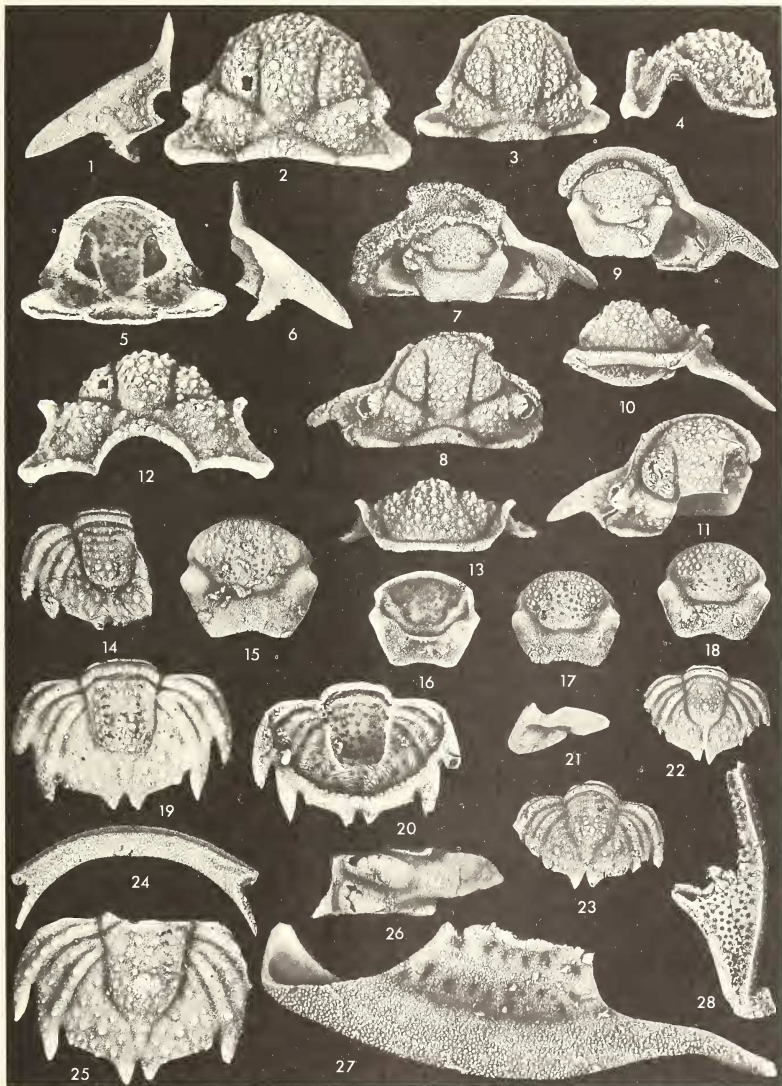
*Paratypes.* ANU35154, 35160, 35166 from loc. G608; ANU35155, 35159, 35165, 35166 from loc. G609; ANU35158, 35163 from loc. G607; and ANU35274 from G527.

*Derivation of name.* This species is named *australiformis* after its similarity to *A. (L.) australis* (McCoy); and *forma*, Latin, shape.

*Diagnosis.* Cranium with palpebral lobes tending to be flattened, standing much lower than the crest of the glabella; genal spine with length (tr.) about twice its basal dimensions, flattened in profile; cranial ornament of coarse tubercles with a scattering of fine tubercles between; tubercles on free cheek and genal spine much sparser than on cranium; rostral plate with ornament of terrace lines along anterior

EXPLANATION OF PLATE 108

- Figs. 1–25. *Acanthopyge (Lobopyge) australiformis* sp. nov. 1, 6, ANU35154, dorsal and ventral views of free cheek,  $\times 5$ , from G608. 2, ANU35155, dorsal view of cranium,  $\times 5$ , from G609. 3–5, ANU35156, dorsal, lateral, and ventral views of cranium,  $\times 5$ , from G609. 7, 8, ANU35157, ventral and dorsal views of holotype cephalon,  $\times 3$ , from G609. 9–11, ANU35158, ventral, anterior, and dorsal views of incomplete cephalon,  $\times 3$ , from G607. 12, ANU35155, posterior view of cranium,  $\times 5.5$ , from G609. 13, ANU35156, anterior view of cranium,  $\times 5$ , from G609. 14, ANU35159, dorsal view of pygidium,  $\times 5$ , from G609. 15, ANU35160, ventral view of hypostome,  $\times 5$ , from G608. 16, 18, ANU35161 (specimen lost), dorsal and ventral views of hypostome,  $\times 5$ , from G609. 17, ANU35162, ventral view of hypostome,  $\times 5$ , from G608. 19, 20, ANU35167, dorsal and ventral views of pygidium,  $\times 5$ , from G608. 21, ANU35274, lateral view of hypostome,  $\times 5$ , from Garra Formation at Wellington Caves. 22, ANU35163, dorsal view of pygidium,  $\times 3$ , from G607. 23, ANU35164, dorsal view of pygidium,  $\times 5$ , from G607. 24, ANU35165, ventral view of rostral plate,  $\times 12$ , from G609. 25, ANU35166, dorsal view of incomplete pygidium,  $\times 5$ , from G608.
- Figs. 26, 27. Cheirurid gen. et sp. indet. 26, ANU35168, dorsal view of incomplete thoracic segment,  $\times 5$ , from G520. 27, ANU35169, external view of free cheek,  $\times 5$ , from G520.
- Fig. 28. Harpid gen. et sp. indet. ANU35170, ventral view of a fragment (part of prolongation) of cephalon,  $\times 5$ , from G513.



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edge. Hypostome about as long as wide; middle body about two-thirds the total hypostomal length; lateral and posterior borders smooth and not inflated; ornament on middle body tuberculate anteriorly and laterally, but pitted posteromedially. Pygidium with gently tapering bluntly rounded axis, but with a narrow variable post-axial ridge extending to the posterior margin; first axial ring always well defined, second much less clear, and subsequent four or five rings vaguely defined or represented by weak apodemes; first two pleural segments with anterior and posterior bands of approximately equal dimensions, the posterior one always being a little more inflated; these segments with short pointed, posteriorly directed spines; third and subsequent pleural segments ill-defined, the third, however, producing a slight marginal angularity that may be a vestigial spine; a pair of posteromedian spines shorter than the anterior pairs and placed close together; doublure extending less than half way from the margin to the axis.

*Discussion.* *A. (L.) australiformis* differs from the closely related but poorly known *A. (L.) australis* (McCoy), from the approximately contemporaneous Ruddock Siltstone of Victoria, in the latter's more prominent palpebral lobes, flatter anterior pleural bands on the first two pygidial segments, and more widely spaced posteromedial spines. The almost complete specimen of *A. (L.) australis* described by Gill (1939) was not a topotype. The type material of *australis* consists of two incomplete cranidia.

*A. (L.) australiformis* differs from *A. (L.) sinuata* (Ratte) in the points listed below under the discussion of that species. The differences between *A. (L.) australiformis* and all known overseas species are so obvious as to need no discussion. However, attention is drawn to the remarkable similarity of the cranidium and hypostome of *A. (L.) erinacea* Haas from the Pragian of Turkey (Haas 1968) despite clear differences in the pygidium.

The presence of both pits and tubercles on the hypostome of this species is noted but its significance is not understood. Some species of *Acanthopyge* such as *A. (M.) bifida* and *A. (L.) sinuata* (Ratte) have entirely tuberculose ornament on the hypostome, whereas other species such as *A. (A.) consanguinea*, *A. (A.) haueri*, and *A. (L.) branikensis* have pits only.

#### *Acanthopyge (Lobopyge) sinuata* (Ratte, 1886)

Plate 109, figs. 1-21

1886 *Lichas sinuata* Ratte, p. 1065, pl. 15, fig. 15.

1887 *Lichas palmata* var. *sinuata* emend. from *L. sinuata* Ratte; Ratte, p. 95, pl. 1, fig. 6.

*Holotype.* Pygidium AMF2484 from the Garra Formation, Wellington Caves.

*Other material.* Topotypes ANU35220-35221, 35223-35227, 35229 from loc. G607; ANU35222, 35228, 35230 from loc. G609.

*Diagnosis.* Cranidium with a distinctive pattern of major tubercles, consisting of a median occipital tubercle flanked by a pair of slightly smaller tubercles and several secondaries, two large tubercles towards the anterolateral corner of the posterolateral lobes, two pairs (three in some specimens) on the median lobe in addition to those on 1p and six tubercles along anterior border; scattered tubercles of various sizes elsewhere over the entire cephalon. Rostral plate with six tubercles and a terrace line



along anterior margin. Hypostome three-quarters as long as wide, and with the length of the middle body only about half the median length; lateral borders gently arched and bearing a row of weak tubercles; posterior border with a slight median swelling, but smooth; middle body with tubercles of two sizes, but no pits. Pygidium with first axial ring complete; second axial ring weaker medially, set much lower than the first, only about half the height and length of the first ring, and separated from first ring by a small pseudo-half-ring; subsequent rings incomplete and vaguely defined by apodomes laterally; first two pleural segments well defined by broad interpleural furrows, and with distinct pleural furrows separating off posterior pleural bands that are about twice the anterior bands in height and length; subsequent pleural segments ill-defined; first marginal spine simple and blade-like; second spine much broader based and with a small subsidiary anterior spine that is about the same size as the clearly defined third spine; posterior spines close together; ornament of scattered tubercles; doublure extending half way from the margin to the axis.

*Discussion.* Ratte's original description of this species is interesting because it constitutes a very early example of the preparation of silicified fossils from limestones by etching with hydrochloric acid.

Specimens occur at the same horizons and sometimes in the same samples as *A. (L.) australiformis*, suggesting the possibility of sexual dimorphism. The differences between them, however, extend to every part of the exoskeleton (see below). Dimorphism in other lichids is not known to produce such profound effects, though it should be noted that it does affect many elements in phacopids (Campbell 1977). We prefer to regard the two morphs as separate species. In this regard, it is worth noting that *A. (L.) australiformis* occurs through almost 200 m of section below the first appearance of *A. (L.) sinuata*.

As compared with *A. (L.) australiformis*, *A. (L.) sinuata* has coarser cephalic tubercles with a more definite pattern; less elongate posterolateral extremities on the rostral plate; tubercles along the anterior part of the rostral plate; longer genal spines; a relatively shorter and less anteriorly arched hypostome, with a shorter middle body ornamented by tubercles without pits; differently proportioned anterior and posterior pygidial pleural bands; a secondary spine on the second pygidial marginal spine; and a smaller space between the third and posterior marginal spines.

### *Acanthopyge (Lobopyge) sp.*

Plate 109, figs. 22, 23

*Material.* ANU35231-35232 from the middle Warroo Limestone, late Emsian, Patmore's property near Good Hope, Yass, N.S.W.

*Discussion.* These two specimens are included here for the sake of completeness. They have been discovered since Chatterton's (1971) work was published. They clearly belong to *A. (Lobopyge)*, but just as clearly they are specifically distinct from the two species described above. Their anterior pleural bands are expanded, all their marginal spines are relatively shorter, the third (vestigial) spine is barely distinguishable, and the tuberculation is much weaker. In many of these respects they have more in common with *A. (L.) australis* than with the Garra species.

## Lichid gen. et sp. indet.

Plate 104, figs. 25, 26

*Material.* ANU35150–35151 from loc. G503.

*Discussion.* A fragment of a hypostome and half a thoracic segment from the one locality are probably from the same species. The hypostome is large and transverse, has a gently convex anterior edge and lateral borders that continue forward to the anterior edge with only a slight indentation for the antennular notch. The middle body is only half the total length, and the middle furrow is sharply impressed. Deep pits cover the middle body and the borders except at the anterolateral corners, where there are a few tubercles and coarse terrace lines. The thoracic segment is probably from near the front of a thorax and has a gently curved, scimitar-like pleural tip. There is a row of rare large tubercles across it.

The hypostome is similar in the shape and proportions of some of its elements, and in the pitting of the borders, to some species of *Hemiarges*, but it could equally well be compared with the hypostome of *A. (A.) consanguinea* (Clarke).

Family ODONTOPLEURIDAE Burmeister, 1843

Genus LEONASPIS Richter and Richter, 1917

*Type species.* *Odontopleura leonhardi* Barrande, 1846, from the Silurian (Budnany) of Czechoslovakia.*Leonaspis wellingtonensis* sp. nov.

Plate 110, figs. 1–15

?1964 *Leonaspis* sp. Strusz, p. 96, pl. 1, figs. 3, 4.*Holotype.* Cranidium ANU35254 from loc. G529.

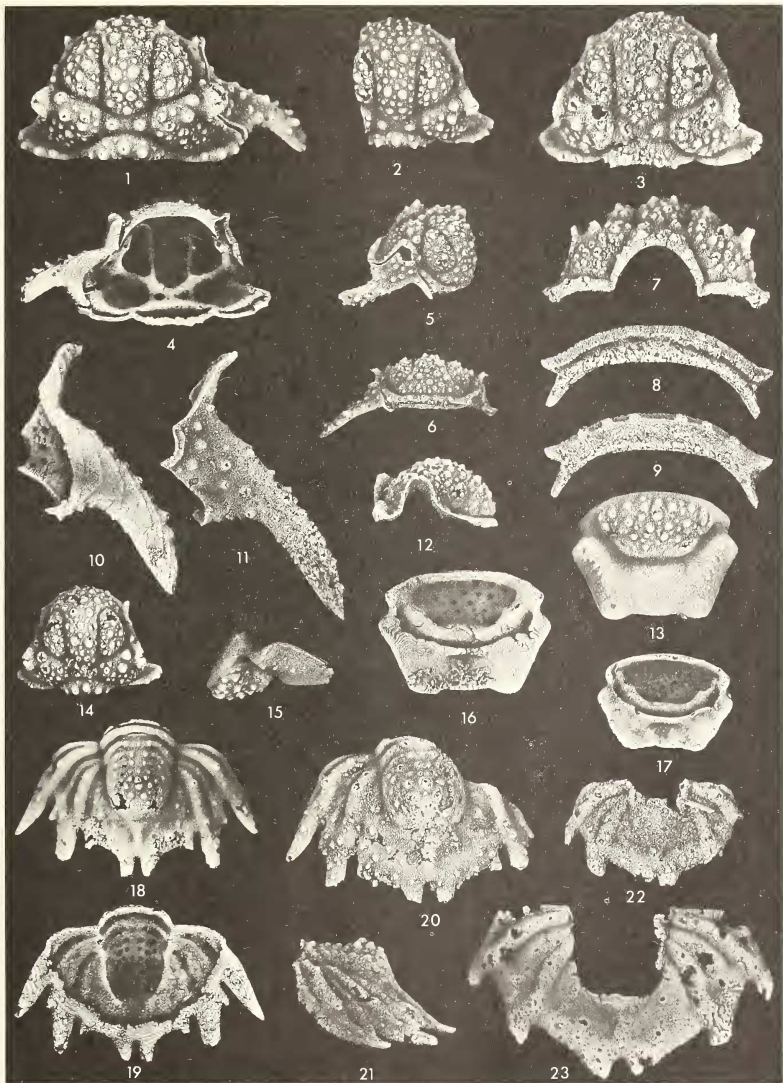
*Paratypes.* ANU35253, 35255, 35258, 35262, 35263, 35266 from loc. G529; ANU35256, 35257, 35260, 35264, and 35267 from loc. G527; ANU35259 and 35265 from loc. G532. All specimens from the Garra Formation.

*Derivation of name.* This species is named after the town of Wellington that is close to the type locality.

## EXPLANATION OF PLATE 109

Figs. 1–21. *Acanthopyge (Lobopyge) sinuata* (Ratte, 1886). 1, 4, 5, 6, ANU35220, dorsal, ventral, anterodorsolateral, and anterior views of incomplete cephalon,  $\times 5$ ,  $\times 4.5$ ,  $\times 3$ , and  $\times 3$ , from G607. 2, 12, ANU35221, dorsal and lateral views of incomplete cranidium,  $\times 3$ , from G607. 3, 7, ANU35222, dorsal and posterior views of cranidium,  $\times 5$ , from G609. 8, 9, ANU35223, dorsal and ventral views of a rostral plate,  $\times 8$ , from G607. 10, ANU35224, ventral view of free cheek,  $\times 5$ , from G607. 11, ANU35225, dorsal view of free cheek,  $\times 5$ , from G607. 13, 15, 16, ANU35226, ventral, lateral, and dorsal views of hypostome,  $\times 5$ , from G607. 14, ANU35227, dorsal view of cranidium,  $\times 4$ , from G607. 17, ANU35228, dorsal view of hypostome,  $\times 5$ , from G609. 18, 19, ANU35229, dorsal and ventral views of pygidium,  $\times 5$ , from G607. 20, 21, ANU35230, dorsal and lateral views of pygidium,  $\times 5$ , from G609.

Figs. 22, 23. *A. (Lobopyge)* sp. Specimens from middle of Warroo Limestone Member on Patmore's Property, near Good Hope. 22, ANU35231, dorsal view of pygidium,  $\times 5$ . 23, ANU35232, dorsal view of pygidium,  $\times 5$ .



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*Diagnosis.* Occipital spine short and pointed; ornament of sparse fine tubercles; genal caeca present on the free cheeks; large and distinct lateral glabellar lobes 1p and 2p, with 2p being only slightly smaller than 1p; approximately 12 pairs of border spines on the free cheeks; 1-3 spines projecting from the dorsomedial surface of the genal spine; and a row of about 10-12 moderately sized tubercles on the narrow anterior border. A broad and relatively flat pygidium; major border spines similar in diameter to and only slightly longer than the adjacent secondary spines; one pair of secondary spines between the major spines; four pairs of anterolateral spines, the ones in the anterior corners being very small; three or four tubercles on each axial ring, a cluster of 6-8 similar tubercles on the lateral pleural field, one on the major pleural ridge, and occasional ones elsewhere.

*Discussion.* *Leonaspis wellingtonensis* shares with *L. clavatus* Chatterton, 1971, from strata of Emsian (late Pragian-Zlichovian) age at Good Hope, near Yass, N.S.W., and *L. rattei* (Etheridge and Mitchell), from the Lochkovian Elmside Formation near Yass (see Ratte 1887; Etheridge and Mitchell 1896; and Chatterton 1971), short occipital spines, few spines on the dorsomedial surface of the genal spines, an ornament of moderate to fine tubercles that are not densely packed, and the presence of only one pair of well-developed (although smaller) border spines between the major border spines of the pygidium.

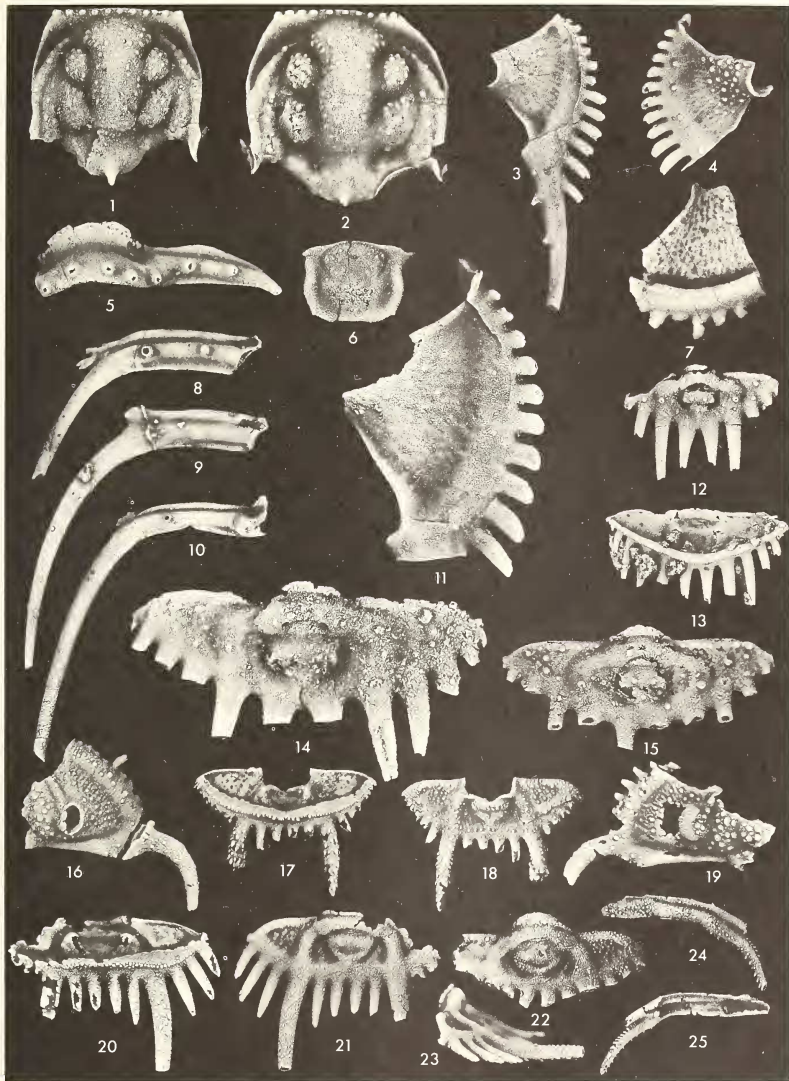
*L. wellingtonensis* differs from *L. clavatus* in having an ornament of somewhat finer and sparser tubercles; slightly broader fixed cheeks with more prominent palpebral ridges; genal caeca more distinct on the free cheeks; deeper posterior and lateral border furrows; slightly longer border spines on the free cheeks, the spines being less blunt distally; a greater number of border spines on the pygidium, there being less of a distinction between the major and minor border spines; and a somewhat broader and less vaulted pygidium.

*L. wellingtonensis* differs from *L. rattei* in having a sparser ornament of tubercles, usually having more spines on the dorsomedian side of the genal spine, shorter and

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EXPLANATION OF PLATE 110

- Figs. 1-15. *Leonaspis wellingtonensis* sp. nov. 1, ANU35253, anterodorsal view of cranium,  $\times 5$ , from G520. 2, ANU35254, anterodorsal view of holotype cranium,  $\times 5$ , from G520. 3, ANU35255, external view of free cheek,  $\times 5$ , from G520. 4, ANU35256, external view of incomplete free cheek,  $\times 5$ , from G527. 5, ANU35257, dorsal view of thoracic segment,  $\times 5$ , from G527. 6, ANU35258, ventral view of hypostome,  $\times 5$ , from G520. 7, ANU35259, internal view of incomplete free cheek,  $\times 5$ , from G532. 8, ANU35260, dorsal view of incomplete thoracic segment,  $\times 5$ , from G527. 9, ANU35261, dorsal view of incomplete thoracic segment,  $\times 5$ , from G527. 10, ANU35262, dorsal view of incomplete thoracic segment,  $\times 5$ , from G520. 11, ANU35263, external view of incomplete free cheek,  $\times 5$ , from G520. 12, ANU35264, dorsal view of pygidium,  $\times 5$ , from G527. 13, ANU35265, ventral view of pygidium,  $\times 5$ , from G532. 14, ANU35266, dorsal view of pygidium,  $\times 5$ , from G520. 15, ANU35267, dorsal view of pygidium,  $\times 5$ , from undetermined horizon in Garra Formation at Wellington Caves.
- Figs. 16-25. *Primaspis (Taemasaspis)* spp. 16, ANU35268, dorsolateral view of fragment of cephalon,  $\times 5.5$ , from G607. 17, 18, ANU35269, ventral and dorsal views of pygidium (type A),  $\times 5.5$ , from G607. 19, ANU35270, dorsal view of fragment of cephalon,  $\times 5$ , from G607. 20, 21, 23, ANU35271, ventral, dorsal, and lateral views of pygidium (type B),  $\times 5.5$ , from G607. 22, ANU35272, dorsal view of pygidium (type B),  $\times 5$ , from G609. 24, 25, ANU35273, dorsal and ventral views of thoracic segment,  $\times 5.5$ , from G607.



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blunter border spines on the free cheeks, and slightly less distinct major border spines on the pygidium.

In some characters, *L. wellingtonensis* is intermediate morphologically between the Lochkovian *L. rattei* and the Emsian *L. clavatus*, including the length and degree of bluntness of the border spines of the free cheeks and the number of spines on the dorsomedian edge of the genal spines.

The group of species discussed above shows some similarity to *L. williamsi* Whittington, from the Lower Devonian Haragan Shale of Oklahoma (see Whittington 1956a; Campbell 1977), but *L. clavatus* is probably the most similar of the Australian species to *L. williamsi*. All the Australian species differ from *L. williamsi* in having a distinctly finer ornament.

#### Genus PRIMASPIS Richter and Richter, 1917

*Type species. Odontopleura primordialis* Barrande, 1846, from the Llandeilo of Czechoslovakia (see Prantl and Přibyl 1949).

*Discussion.* Přibyl and Vaněk (1965) subdivided *Primaspis* into three subgenera, *Primaspis (Primaspis)*, *P. (Meadowtownella)*, and *P. (Chlustinia)*. Bruton (1968) considered that Přibyl and Vaněk had over-estimated the differences between the first two of these, and considered *P. (Primaspis)* and *P. (Meadowtownella)* to be synonyms. Bruton (1968) considered that the forms included in *P. (Chlustinia)* are sufficiently distinct from the other species of *Primaspis* for *Chlustinia* to be raised to generic rank. Bruton (1967) erected the genus *Anacaenaspis* for certain Silurian species of the *Primaspis* group, and Chatterton (1971) proposed a subgenus of *Primaspis*, *P. (Taemasaspis)*, for two Australian and one European species, the subgenus ranging from Wenlock to Emsian. Přibyl and Vaněk (1973) then considered both *Anacaenaspis* and *P. (Taemasaspis)* to be junior synonyms of *P. (Meadowtownella)*.

In describing our fauna it has been necessary for us to attempt a resolution of the above conflicting opinions. We agree with Bruton (1968) that *Chlustinia* is worthy of generic rank, and the problem thus becomes one of determining the relationships between *P. (Primaspis)*, *P. (Meadowtownella)*, *P. (Taemasaspis)*, and *Anacaenaspis*. The type species of *Taemasaspis*, *P. (T.) campbelli* Chatterton differs significantly, in our opinion, from the type species of *P. (Primaspis)*, *P. (Meadowtownella)*, and *Anacaenaspis*. It differs from the two Ordovician type species, *P. (P.) primordialis* and *P. (M.) whitei* (Whittard), in that it has the free cheeks fused to the cranium in mature specimens, the eye ridges run in a straight line from the eyes to the front of the glabella, the genal spine is more laterally directed and curved, the 3p lobes are very small and distinctly separated from the median lobe, and the genal spine projects from a point further forward on the cephalon. The hypostome of *P. (T.) campbelli* is quite distinct from that of *P. ascitus* Whittington, an Ordovician form included by Přibyl and Vaněk (1965) in *Meadowtownella*, in that it lacks shoulders. *P. (T.) campbelli* differs from the type species of *Anacaenaspis*, *A. gotlandensis* Bruton, in that the eye ridges run straight from the eyes to the front of the glabella, the genal spines are more laterally directed, and the posterior pleural spines of the thorax lack a

posterior articulatory notch distal to the fulcrum. We consider that, for the present, *Anacaenaspis* should be regarded as a subgenus of *Primaspis*, but it may yet prove to be a synonym of *P. (Meadowtownella)* and/or *P. (Primaspis)*.

*Primaspis s.l.* appears to have undergone a form of mosaic evolution, with several strong chronoclines that allow us to distinguish Devonian from Ordovician species, the Silurian forms being intermediate. These chronoclines are: fusion of the facial suture with maturity, migration forward of the base of the genal spine, an increase in the lateral projection and curvature of the genal spine, an increase in the rectilinearity of the eye ridge, and an increase in the separation of 3p from the median lobe of the labella.

#### Subgenus PRIMASPIS (TAEMASASPIS) Chatterton, 1971

*Type species. Primaspis (Taemasaspis) campbelli* Chatterton from the Warroo Limestone, Emsian, near Taemas, N.S.W.

#### *Primaspis (Taemasaspis) spp.*

Plate 110, figs. 16–25

*Material and locality.* ANU35268–35273 from loc. G607; and ANU35272 from loc. G609, Garra Formation.

*Discussion.* Two fragments of cephalae, one fragment of a thoracic segment, and two distinct types of pygidia are referred to this subgenus. It has not been possible to associate the cephalic fragments with one or other of the pygidia. The cephalae have the characteristic genal spines of the subgenus, but they can be distinguished from the type species by the absence of fine granules in the lateral border furrows.

The pygidia of type A. (Pl. 110, figs. 17, 18) are characterized by relatively weak pleural ridges that curve only slightly lateral to the axis before running back almost straight; broad pleural fields that are only slightly depressed lateral to the pleural ridges; median secondary border spines that are only half the dimensions of the major border spines; five pairs of lateral secondary border spines that diminish gradually in diameter forwards (their length being unknown); sparse, even granules on the dorsal exoskeleton, but elongate posteriorly directed granules on the ventral and lateral surfaces of at least the major border spines, and a doublure ridge that is convex rather than embayed posteromedially. All these features permit differentiation from *P. (T.) campbelli* Chatterton, *P. (T.) bowningensis* (Etheridge and Mitchell) and the other species represented in this fauna. In addition, *bowningensis* (see Chatterton 1971, pl. 23, fig. 8) has more needle-like marginal spines over-all.

Compared with type A, the pygidia of type B have stronger pleural ridges, more depressed lateral pleural fields, three rather than five anterolateral spines, more closely spaced dorsal granules, and a broadly embayed doublure ridge posteromedially. The size and number of the marginal spines distinguish it readily from *bowningensis*, and the size of the lateral pleural fields and the number of anterolateral spines distinguish it from *campbelli*.

The thoracic segment is not distinctive.

Genus *KONEPRUSIA* Prantl and Přibyl, 1949

*Type species. Acidaspis fuscina* Novák, 1883 (by original designation), from the Branik Limestones, Eifelian, at Koněprusy, Bohemia.

*Diagnosis.* Odontopleurid trilobites with or without a median occipital spine but without lateral occipital spines, and with or without a clearly defined band to the occipital ring; prominent 1p and 2p lobes; 3p lobes small and sometimes indistinct; short posteriorly placed palpebral lobes; eye ridges strongly curved; free cheeks having a curved lateral margin, the greatest width behind the mid-length, fine, short to very short marginal spines usually restricted to the posterolateral parts, and prominent genal spines that project from a point slightly above and partly within the lateral margin; thoracic segments that end distally in moderate to long, usually downturned and barbed anterior pleural spines, and larger horizontal or slightly upturned posterior pleural spines. Pygidia with a pair of prominent major border spines; with or without a prominent posteromedian border spine and with or without fine marginal spines.

Subgenus *KONEPRUSIA* (*KONEPRUSIA*) Prantl and Přibyl, 1949

*Diagnosis.* Occipital ring without a median occipital spine or a distinct posterior band. Semicircular to subtriangular pygidia with a pair of prominent major border spines and a prominent posteromedian border spine.

Subgenus *KONEPRUSIA* (*ISOPRUSIA*) Bruton, 1966

*Diagnosis.* Occipital ring with a strong median spine and with or without a distinct posterior band. Anterior spines on thoracic segments very long and barbed along anterior and posterior edges. Pygidium with two strong major border spines, usually lacking a strong median spine, and with or without very fine anterolateral marginal spines.

*Discussion.* Bruton (1966) pointed out that the type specimen of the type species of *Koneprusia*, showing the thorax and part of the cephalon, has been lost. It is known only from imperfect illustrations (Novák 1883, pl. 10, fig. 19a; Prantl and Přibyl 1949, pl. 3, fig. 26; pl. 5, fig. 2). He suggested that the only really distinctive feature of this genus known at that time was the prominent posteromedian marginal spine on the pygidium that occurs with a pair of prominent major border spines. This contrasts with the very similar *Isoprusia*, which lacks the posteromedian border spine. Several odontopleurid pygidia with three prominent marginal spines have since been assigned to *Koneprusia* (Bruton 1966; G. K. B. Alberti 1970; Ormiston 1969, 1975). Parts of cephalon have been tentatively assigned to *Koneprusia* by Prantl and Přibyl (1949—a cephalon), Haas (1969—a cranidium), G. K. B. Alberti (1970—a cranidium), Perry and Chatterton (1976—a free cheek and fragment of a cranidium), and Ormiston (1975—a cranidium). None of these parts of cephalon could be definitely associated with the distinctive three-spined pygidium of *Koneprusia*, and indeed the last three forms could equally well be assigned to *Isoprusia*. Consequently, in the above



diagnosis we have not listed any characters that are known only from these specimens or the species *K. ? insolita* Haas.

In the Garra faunas there are several cranidia, free cheeks and thoracic segments that can be associated with three-spined *Koneprusia* pygidia because of their occurrence in the same samples, their similarity of ornament, and the fact that they obviously do not belong to other odontopleurid taxa in the fauna whose cephalae are well known. The morphology of the cranidia differs from that of species of *Isoprusia* in lacking occipital spines (this portion of the type specimen of *K. fuscina* is missing in the illustrations of Novák 1883, and Prantl and Přibyl 1949). However, other features of the cranidia, particularly the transverse anterior border, the expanded anterior glabellar lobe, and the strongly curved eye ridges are similar to those of the cranidia of *Isoprusia* illustrated by Bruton (1966). In addition, the shape of the free cheeks and their small marginal spines, the shape and orientation of the anterior and posterior pleural spines on the thoracic segments, and the gross form and general spine pattern of the pygidium, are similar to those of *Isoprusia*. All these facts tend to support the suggestion of such workers as Haas (1969) and Perry and Chatterton (1976) that *Isoprusia* should be considered as a subgenus of *Koneprusia*.

*Koneprusia (Koneprusia) brikelos* sp. nov.

Plate 111, figs. 1-17

*Holotype*. Cranidium ANU35233, from loc. G612.

*Paratypes*. ANU35234, 35238, 35240, 35242, 35246 from loc. G527; ANU35235, 35236, 35243 from loc. G546; ANU35237, 35239, 35241 from loc. G609; and ANU35245 from loc. G608.

*Derivation of name*. *Brikelos*, Greek, a tragic mask, from a general impression conveyed by the cranidium.

*Diagnosis*. Occipital ring with a weak occipital node; fixed cheek on the median side of the eye ridge about twice the width of the eye ridge; axial furrow distinct; cranial tubercles of two distinct sizes indiscriminately commingled; tubercles on occipital ring slightly larger than elsewhere; marginal spines on free cheek reduced to slightly enlarged and pointed tubercles restricted to the posterolateral edge of the cheek. Thoracic pleurae made up almost entirely of the posterior band, with a distinct anterior and a much weaker posterior flange. Anterior pleural spines (all broken in available specimens) almost vertical, some with barbed spines and others with granules on their edges; rings, pleural bands, and proximal portions of posterior spines with tubercles slightly smaller than those on the cranidium. Pygidium with a posteromedian border spine that is shorter and finer than a pair of prominent major border spines that projects slightly (10-20 degrees) above horizontal; no fine marginal spines on the pygidium; an ornament of fine tubercles.

*Discussion*. The cephalon of *K. ? ursula* (Barrande, 1872) which came from the same area, but not the same horizon, as the type specimen of the type species of *Koneprusia*, *K. (K.) fuscina*, was considered by Prantl and Přibyl (1949) to be a possible senior synonym of *K. (K.) fuscina* and thus may be representative of the type species. The pygidium is unknown, but the features of the cephalon of *K. ? ursula* are

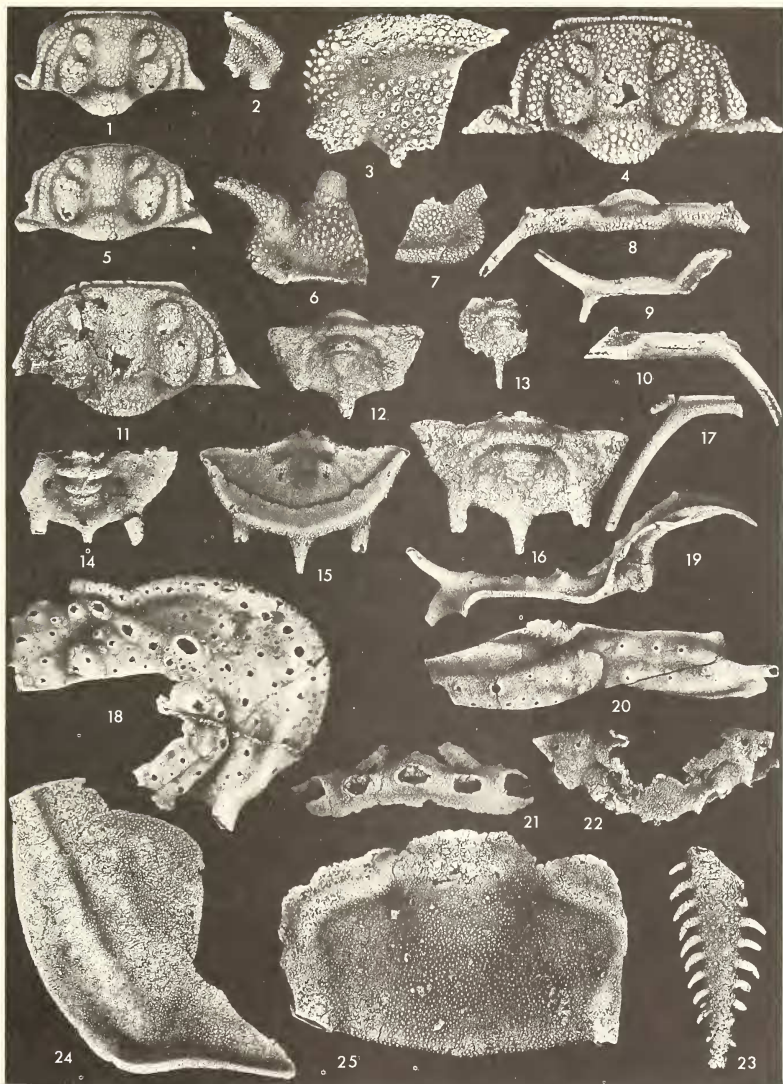
similar to those of *K. (K.) brikelos* n. sp. and only appear to differ in having a row of tubercles on the anterior border, a prominent occipital spine, a slightly coarser ornament of tubercles (this feature varies ontogenetically in *K. (K.) brikelos*), and in having no small 3p lobe visible (see Barrande 1872, pl. 16, fig. 18). Bruton (1966) included this species in *Isoprusia* on the basis of the similarity of its cephalon to that of the type species, *I. mydlakia*, and with this opinion we are in agreement. The pygidium of *K. (K.) brikelos* differs from that of *K. (K.) fuscina* in that its furrows are shallower, the posteriomedian border spine is relatively smaller, and the pleural ribs leading to the major border spines are not as pronounced.

The pygidium of *K. (K.) brikelos* differs from that of *K. ? subterarmata* (Barrande) (refigured by Bruton 1966, pl. 57, figs. 15, 17, 18) in that its outline is slightly more semicircular; it has no fine secondary marginal spines; no fine pits in the dorsal surface of the pleurae but a slightly greater number of tubercles; less prominent pleural ribs leading to the major border spines; a larger terminal piece to the axis; and a smaller second axial ring. The pygidium of *K. (K.) brikelos* differs from the *Koneprusia* pygidium illustrated by Ormiston (1975) from the Emsian McCann Hill Chert of Alaska in lacking prominent pits in the pleural regions, having shallower furrows, no fine secondary marginal spines, a more semicircular outline, a more distinct second axial ring, and slightly less upturned major border spines.

The cranidium assigned to *Koneprusia* by Ormiston (1975) from the Delorme Formation, Yukon Territory, Canada, may belong to *Isoprusia*, but it differs from *K. (K.) brikelos* in having a prominent occipital spine, having a coarser tuberculose ornament and a broader fixiginal lobe anteriorly. The free cheek and fragmental cranidium from the Delorme Formation assigned to *Koneprusia* by Perry and Chatterton (1976) are close to those of *K. (K.) brikelos*, but the free cheek of the Canadian form differs in having a slightly deeper border furrow and slightly larger marginal spines posteriorly.

#### EXPLANATION OF PLATE 111

- Figs. 1-17. *Koneprusia brikelos* sp. nov. 1, 5, ANU35233, anterodorsal and dorsal views of holotype cranidium,  $\times 5$ , from G612. 2, ANU35234, external view of free cheek,  $\times 5$ , from Garra Formation at Wellington Caves. 3, ANU35235, external view of free cheek,  $\times 12$ , from G546. 4, ANU35236, anterodorsal view of cranidium,  $\times 12$ , from G546. 6, ANU35237, external view of incomplete free cheek,  $\times 5$ , from G609. 7, ANU35238, external view of free cheek,  $\times 5$ , from Garra Formation at Wellington Caves. 8, ANU35239, dorsal view of thoracic segment,  $\times 5$ , from G609. 9, 10, ANU35240, anterior and dorsal views of incomplete thoracic segment,  $\times 5$ , from G527. 11, ANU35241, anterodorsal view of cranidium,  $\times 5$ , from G609. 12, ANU35242, dorsal view of pygidium,  $\times 5$ , from Garra Formation at Wellington Caves. 13, ANU35243, dorsal view of incomplete pygidium,  $\times 5$ , from G546. 14, ANU35244, dorsal view of pygidium,  $\times 5$ , from G520. 15, 16, ANU35245, ventral and dorsal views of pygidium,  $\times 5.5$ , from G608. 17, ANU35246, dorsal view of incomplete thoracic segment,  $\times 5$ , from G527.
- Figs. 18-23. *Ceratocephala* sp. nov. A. 18, ANU35247, dorsal view of a portion of cephalon,  $\times 3$ , from G520. 19, 20, ANU35248, anterior and dorsal views of incomplete thoracic segment,  $\times 3$ , from G514. 21, 22, ANU35249, posterior and dorsal views of pygidium,  $\times 5$ , from G609. 23, ANU35250, dorsal(?) view of pygidial border spine,  $\times 5$ , from G520.
- Figs. 24, 25. *Dicranurus?* sp. 24, ANU35251, external view of anterolateral portion of cranidium,  $\times 5$ , from G519. 25, ANU35252, dorsal view of pygidium,  $\times 5$ , from G520.



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## Genus DICRANURUS Conrad, 1840

*Type species.* *Acidaspis hamata* Hall, 1859, from the Lower Devonian of New York.

*Dicranurus?* sp.

Plate 111, figs. 24, 25

*Material.* ANU35251 from loc. G519, and ANU35252 from loc. G520.

*Discussion.* In the collection there are an incomplete pygidium and a fragment of a cranidium that are both odontopleurid and have matching preservation and ornament. The pygidium clearly has a pair of major border spines with no other border spines between them, and hence if it does not belong to an entirely new genus, it probably belongs to *Dicranurus*, *Isoprusia*, or *Selenopeltis*. The shallow furrows and low ridges on our specimens, the tendency for the pleural ribs of the pygidium to run slightly posterolaterally before turning backward to join the major border spines, and the known occurrence of *Dicranurus* elsewhere in the Devonian of Australia (*D. longispinus* (Mitchell) from the earliest Devonian of the Yass District, and *D. kinglakensis* Gill from the Pragian of Victoria), all would favour the assignment of these specimens to *Dicranurus*. *D. kinglakensis* is similar to *D.?* sp. in having the pleural ribs run outward slightly posterolaterally before turning backward, but differs in having slightly deeper furrows and a more convex axis.

## Genus CERATOCEPHALA Warder, 1838

*Type species.* *Ceratocephala goniata* Warder, 1838, from the middle Silurian of Springfield, Ohio, U.S.A.

*Ceratocephala* sp. nov. A

Plate 111, figs. 18-23

*Material.* ANU 35247 and ANU 35250 from loc. G520; ANU 35248 from loc. G514; and ANU 35249 from loc. G609.

*Discussion.* Incomplete cephalon, a thoracic segment, and fragments of pygidia were the only fragments obtained. These specimens all have an ornament of sparse medium sized tubercles. The pygidium apparently originally had five prominent pairs of barbed marginal spines. Some specimens have fine tubercles between the larger tubercles. Material of more than one species may be represented in our collections. Species of this genus have previously been described from several localities in New South Wales, including several species from the earliest Devonian of the Yass Basin and *Ceratocephala vexilla* Chatterton from strata of Emsian age just south of the Yass Basin, near Good Hope. The fragments of *Ceratocephala* sp. nov. A are not particularly close to *C. vexilla*, and are probably closest to *C. vogdesi* Etheridge and Mitchell from strata of earliest Devonian age at Bowning near Yass. They differ from that species, however, in having sparser tubercles, with no sign of the larger tubercles being compound. Both forms are comparatively large.

There is some similarity between *C.* sp. nov. A and *C. vesiculosa* (Beyrich, 1846) from the Pragian Upper Koněprusy Limestone of Czechoslovakia, but a detailed comparison can not be made until more material is obtained from the Garra Formation.

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## REFERENCES

- ALBERTI, G. K. B. 1967. Neue obersilurische sowie unter- und mitteldevonische Trilobiten aus Morokko, Deutschland, und einigen anderen europäischen Gebieten. *Senckenberg. leth.* **48**, 463–509, pls. 1, 2.
- 1969. Trilobiten des jüngeren Siluriums sowie des Unter- und Mitteldevons. I. Mit Beiträgen zur Silur-Devon-Stratigraphie einiger Gebiete Marokkos und Oberfrankens. *Abh. senckenb. naturforsch. Ges.* **520**, 1–692, pls. 1–52.
- 1970. Trilobiten des jüngeren Siluriums sowie des Unter- und Mittel-devons. II. *Ibid.*, **525**, 1–233, pls. 1–20.
- ALBERTI, H. 1969. Trilobiten (Harpidae und Odontopleuridae) aus dem Devon des Harzes und des Rheinischen Schiefergebirges (Beitrag II). *Geol. Jb.* **87**, 361–382, pls. 22, 23.
- BARRANDE, J. 1846. *Notice préliminaire sur le Système Silurien et les trilobites de Bohême*. vi+97 pp., Leipsic.
- 1852. *Système Silurien du centre de la Bohême. 1ère partie: Recherches paléontologiques*. Vol. 1. *Crustacés: Trilobites*. xxx+935 pp., 51 pls., Prague and Paris.
- 1872. *Système Silurien du centre de la Bohême. 1ère partie: Recherches paléontologiques, supplément au vol. 1*. xxx+647 pp., Atlas of 35 pls., Prague and Paris.
- BRUTON, D. L. 1966. A new odontopleurid trilobite genus from the Devonian of Bohemia. *Palaeontology*, **9**, 330–345, pls. 55–57.
- 1967. Silurian odontopleurid trilobites from Sweden, Estonia, and Latvia. *Ibid.* **10**, 214–244, pls. 30–36.
- 1968. A revision of the Odontopleuridae (Trilobita) from the Paleozoic of Bohemia. *Skr. Norske Vidensk.-Akad. mat.-nat. Kl. n.s.*, **25**, 1–73, pls. 1–11.
- CAMPBELL, K. S. W. 1967. Trilobites of the Henryhouse Formation (Silurian) in Oklahoma. *Bull. Okla geol. Surv.* **115**, 1–68, pls. 1–19.
- 1977. Trilobites of the Haragan, Bois d'Arc and Frisco Formations (early Devonian) Arbuckle Mountains Region, Oklahoma. *Ibid.* **123**, 1–139, pls. 1–40.
- CHAPMAN, F. 1915. New or little known Victorian fossils in the National Museum. Part XVIII. Some Yeringian trilobites. *Proc. R. Soc. Viet.* **28**, 157–171.
- CHATTERTON, B. D. E. 1971. Taxonomy and ontogeny of Siluro-Devonian trilobites from near Yass, New South Wales. *Palaeontographica*, **A137**, 1–108, pls. 1–24.
- and CAMPBELL, K. S. W. 1979. Silurian trilobites from near Canberra and some related forms from the Yass Basin. *Ibid.* **A\*\*\***.
- and PERRY, D. G. 1977. Lochkovian trilobites and conodonts from northwestern Canada. *J. Paleont.* **51**, 772–796, pls. 1–4.
- CHLUPAČ, I. 1972. New Silurian and Lower Devonian trilobites from the Barrandian area (Czechoslovakia). *Čas. Miner. Geol.* **17**, 395–401, pls. 1–4.
- DRUCE, E. C. 1970. Conodonts of the Garra Formation (Lower Devonian), N.S.W. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* **116**, 29–52, pls. 4–9.
- EDGELL, H. S. 1955. A Middle Devonian lichid trilobite from south-eastern Australia. *Paläont. Z.* **29**, 136–145, pls. 14, 15.
- ELDRIDGE, N. 1973. Systematics of Lower and lower Middle Devonian species of the trilobite *Phacops* Emmrich in North America. *Bull. Am. Mus. nat. Hist.* **151**, 285–338.

- ETHERIDGE, R. J. and MITCHELL, J. 1893. The Silurian trilobites of New South Wales, with reference to those of other parts of Australia. Part II. The genera *Proetus* and *Cyphaspis*. *Proc. Linn. Soc. N.S.W.* **8**, 169–178, pls. 6, 7.
- 1896. The Silurian trilobites of New South Wales, with references to those of other parts of Australia. Part IV. The Odontopleuridae. *Ibid.* **11**, 694–721, pls. 50–55.
- 1917. The Silurian trilobites of New South Wales, with references to those of other parts of Australia. Part VI. The Calymenidae, Cheiruridae, Harpeidae, Bronteidae, etc. With an Appendix. *Ibid.* **42**, 480–510, pls. 24–27.
- GILL, E. D. 1939. The Silurian trilobite *Lichas australis*. *Mem. natn. Mus. Melb.* **11**, 140–142, pl. 5.
- 1945. Trilobites of the family Calymenidae from the Paleozoic rocks of Victoria. *Proc. R. Soc. Vict.* **56**, 171–186, pl. 7.
- HAAS, W. 1968. Trilobiten aus dem Silur und Devon von Bithynien (NW-Türkei). *Palaontographica*, **A130**, 60–207.
- 1969. Lower Devonian trilobites from central Nevada and northern Mexico. *J. Paleont.* **43**, 641–659, pls. 81–84.
- HALL, J. 1859. *Natural history of New York*, Part 6. *Palaontology: volume 3. Containing descriptions and figures of the organic remains of the Lower Helderberg Group and the Oriskany Sandstone*. xii + 532 pp., Albany.
- JOHNSON, B. D. 1975. The Garra Formation (early Devonian) at Wellington, N.S.W. *J. Proc. R. Soc. N.S.W.* **108**, 111–118.
- KOBAYASHI, T. and HAMADA, T. 1977. Devonian trilobites of Japan in comparison with Asian, Pacific, and other faunas. *Spec. Pap. palacont. Soc. Japan*, **20**, 1–202, pls. 1–13.
- LE MENN *et al.* 1976. IncurSION Hercynienne dans les faunes Rhenanes du Dévonien inférieur de la rade de Brest (Massif Armoricaïn). *Palaontographica*, **A153**, 1–61, pls. 1–10.
- LÜTKE, F. 1965. Zur Kenntnis Herzynischer Trilobiten aus dem Unter- und Mitteldevon des Harzes. *Ibid.* **A124**, 151–236, pls. 17–22.
- MITCHELL, J. 1888. On some new trilobites from Bowring. *Proc. Linn. Soc. N.S.W.* **2**, 435–440, pl. 16.
- NOVÁK, O. 1883. Zur kenntnis der Böhmischn Trilobiten. *Beitr. Paläont. öst.-Ung.* **3**, 23–64, pls. 8–12.
- ORMISTON, A. R. 1969. The trilobite *Koneprusia* in the Lower Devonian of Alaska. *J. Paleont.* **43**, 1210–1212.
- 1975. Siegenian trilobite zoogeography in Arctic North America. *Fossils Strata*, **4**, 391–398, pls. 1–5.
- OWENS, R. M. 1973. The British Ordovician and Silurian Proetidae (Trilobita). *Palacontogr. Soc. [Monogr.]* **127**, 1–98, pls. 1–15.
- PERRY, D. G. and CHATTERTON, B. D. E. 1976. *Phacops* and other trilobites from Emsian age beds of the Delorme Formation, Mackenzie Mountains, Northwest Territories. *Can. J. Earth Sci.* **13**, 1466–1478, pls. 1, 2.
- 1977. Silurian (Wenlockian) trilobites from Baillie-Hamilton Island, Canadian Arctic Archipelago. *Ibid.* **14**, 285–317, pls. 1–7.
- PILLET, J. 1972. Les Trilobites du Dévonien inférieur et du Dévonien moyen du Sud-Est du Massif armoricaïn. *Mém. Soc. étud. sci. Anjou*, **1**, 1–307, pls. 1–64.
- POWELL, C. MCA., EDGECOMBE, D. R., HENRY, N. M. and JONES, J. G. 1976. Timing of deformation of the Hill End trough: a reassessment. *J. geol. Soc. Aust.* **23**, 407–421.
- PRANTL, F. and PŘIBYL, A. 1949. A study of the superfamily Odontopleuracea nov. superfam. (trilobites). *Rozpt. st. geol. Ust.* **12**, 1–221, pls. 1–11.
- PŘIBYL, A. 1965. Proetidní trilobiti z nových sběrů v českém siluru a devonu. I. Část (Proetiden aus neueren Aufsammlungen im böhmischen Silur und Devon (Trilobitee) I.) *Čas. národ. Mus., Odd. přírod.*, **134** (2), 91–98, pls. 7, 8.
- and VANĚK, J. 1965. Neue Trilobiten des böhmischen Ordoviziums. *Vest. ústřed. Ust. geol.* **40**, 277–282.
- 1966. Zur Kenntnis der Odontopleuridae-Trilobiten aus dem böhmischen Altpaläozoikum. *Acta Univ. Carol. Geologica*, **4**, 289–304, pls. 1–10.
- 1973. Über Hypostome von Odontopleuriden (Trilobita) und ihrer Systematik. *Čas. Miner. Geol.* **18**, 301–307.

- RATTE, F. 1886. Note on some trilobites new to Australia. *Proc. Linn. Soc. N.S.W.* **1**, 1065, 1066, pl. 15.  
— 1887. Note on some trilobites new to Australia. *Ibid.* **2**, 95–102, pls. 1, 2.
- RICHTER, R. and RICHTER, E. 1930. Neue Horner-Trilobiten in unsurer Schausammlung. *Natur Mus., Frankf.* **60**, 31–45.
- SHERWIN, L. 1970. Trilobites of the subfamily Phacopinae from New South Wales. *Rec. geol. Surv. N.S.W.* **13**, 83–99, pls. 1–8.
- STRUSZ, D. L. 1964. Devonian trilobites from the Wellington-Molong district of New South Wales. *J. Proc. R. Soc. N.S.W.* **97**, 91–97, pl. 1.  
— 1965a. A note on the stratigraphy of the Devonian Garra Beds of N.S.W. *Ibid.* **98**, 85–90.  
— 1965b. Disphyllidae and Phacellophyllidae from the Devonian Garra Formation of N.S.W. *Palaeontology*, **8**, 518–571, pls. 72–78.  
— 1966. Spongophyllidae from the Devonian Garra Formation of N.S.W. *Ibid.* **9**, 544–598, pls. 85–96.  
— 1967. *Chlamydoxylum*, *Iowaphyllum* and *Sinospongophyllum* (Rugosa) from the Devonian of N.S.W. *Ibid.* **10**, 426–435, pl. 67.  
— 1968. Lower and Middle Devonian of the Molong Geanticline, N.S.W., Australia, pp. 123–133 *In* OSWALD, D. H. (ed). *International symposium on the Devonian System, Calgary, 1967*. Vol. 2, xi+1377 pp., Alberta Society of Petroleum Geologists, Calgary.  
— and JELL, J. S. 1970. *Cyathophyllum* (*Radiophyllum*) from the Devonian of eastern Australia. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* **116** (Palaeont. Pap. 1968), 119–144, pls. 19–24.  
— et al. 1972. Correlation of the Lower Devonian rocks of Australia. *J. geol. Soc. Aust.* **18**, 427–455.
- STRUVE, W. 1958. Die Zeliskellinae. *Senckenberg. leth.* **39**, 165–219, pls. 1–4.
- TALENT, J. A. 1963. The Devonian of the Mitchell and Wentworth Rivers. *Mem. geol. Surv. Vict.* **24**, 1–118, pls. 1–78.  
— 1965. The Silurian and early Devonian faunas of the Heathcote District, Victoria. *Ibid.* **26**, 1–55, pls. 1–27.  
— et al. 1972. Provincialism and Australian early Devonian Faunas. *J. geol. Soc. Aust.* **19**, 81–97.
- TRIPP, R. P. 1957. The classification and evolution of the superfamily Lichacea (Trilobita). *Geol. Mag.* **94**, 104–122.
- VANĚK, J. 1959. Čeled Lichaidae Hawle and Corda 1847 ze Středoešského staršího paleozoika. *Bohem. cent. A. Sci. nat.* **1**, 81–168, pls. 1–8.
- WARDER, J. A. 1838. *Ceratocephala goniata*. *Am. J. Sci.* (1), **34**, 377–379.
- WHITTINGTON, H. B. 1956a. Type and other species of Odontopleuridae (Trilobita). *J. Paleont.* **30**, 504–520, pls. 57–60.  
— 1956b. Beecher's lichid protaspis and *Acanthopyge consanguinea* (Trilobita). *Ibid.* **30**, 1200–1204, pl. 131.
- ZIEGLER, W. 1975. *Catalogue of conodonts*. Vol. 2. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

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